The Engineer

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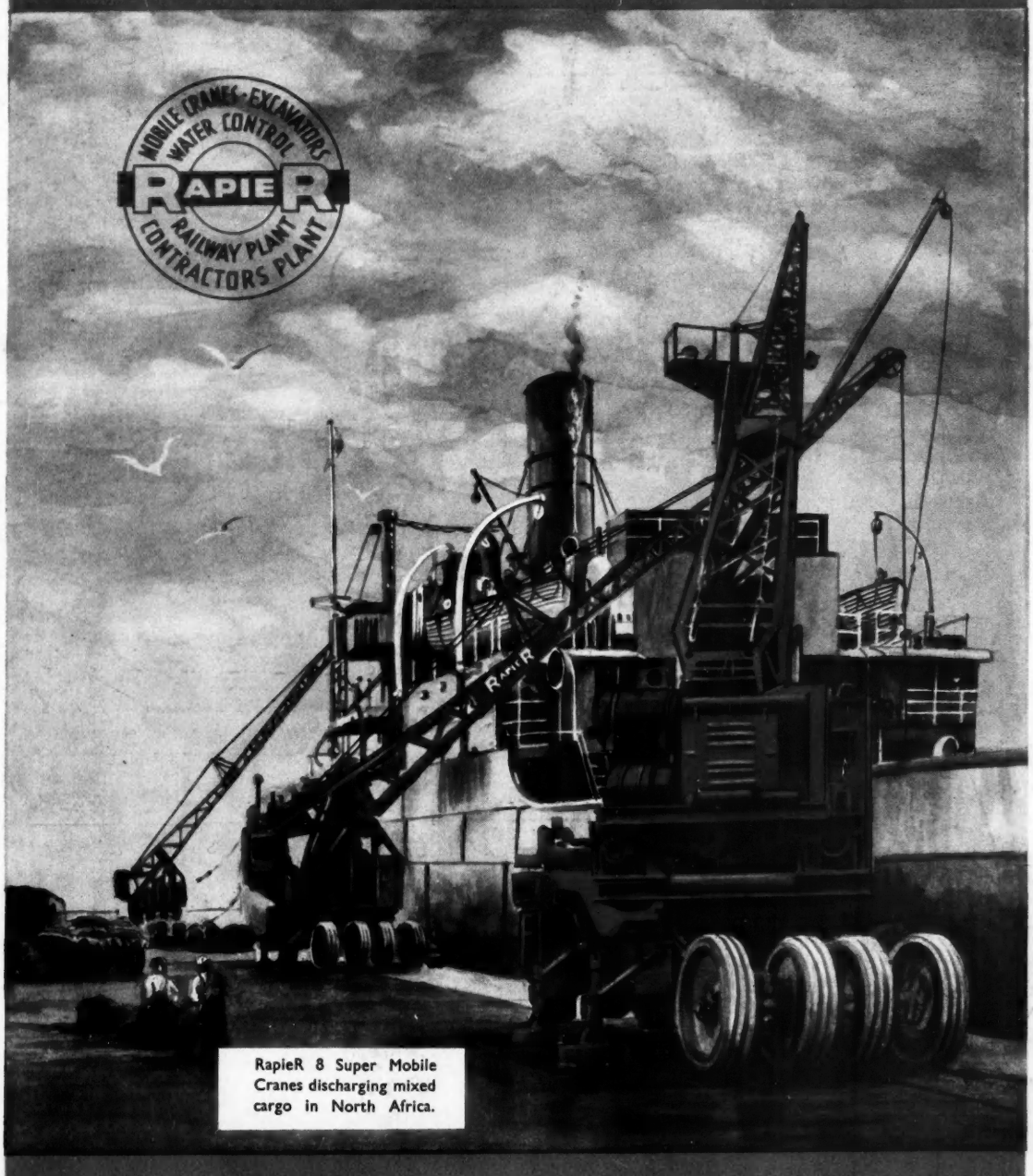

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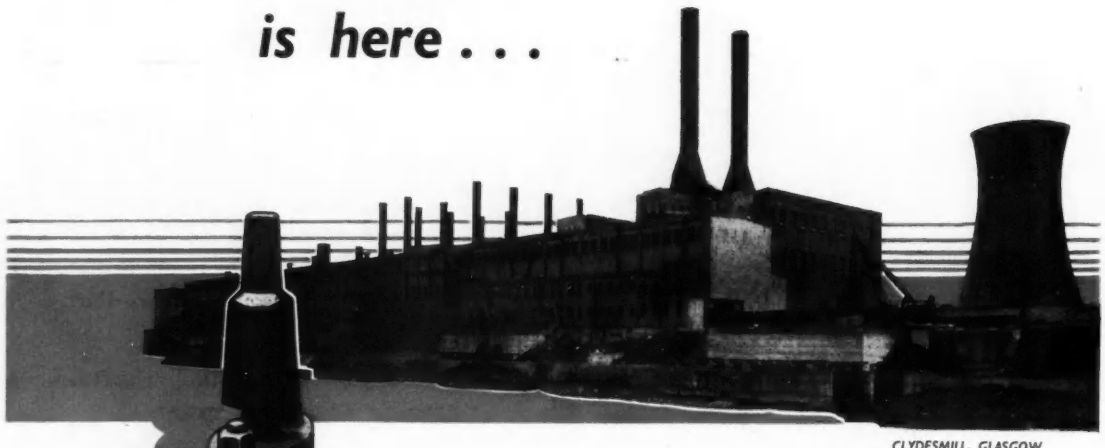

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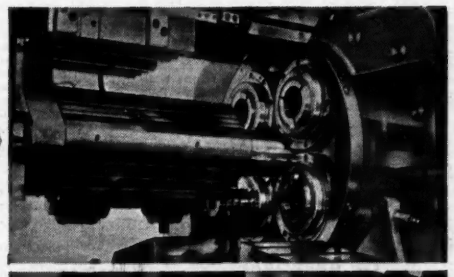
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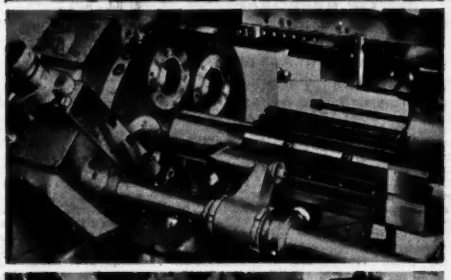
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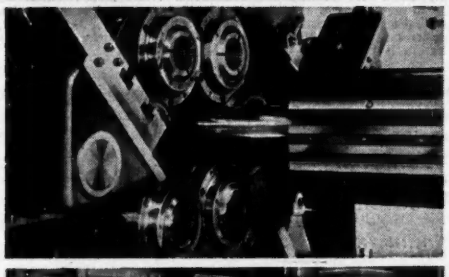
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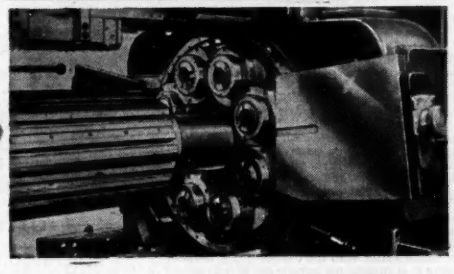
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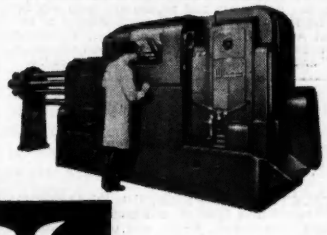

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THE ENGINEER

ESTABLISHED 1856

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JULY 10, 1953

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NOTICE TO READERS

All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

UNIVERSITY OF CAMBRIDGE

FACULTY OF ENGINEERING

UNIVERSITY LECTURER OR UNIVERSITY DEMONSTRATOR

Applications are invited for a post of UNIVERSITY LECTURER or UNIVERSITY DEMONSTRATOR. The duties of a University Lecturer or a University Demonstrator are similar; appointment to either type of post will depend on age and qualifications. Applicants should have been engaged in engineering.

The person appointed will be required to teach primarily in Thermodynamics and Mechanical Engineering. It is hoped that the appointment will be from 1st October, 1953. Scale of salaries, other particulars and forms of application may be obtained from the Secretary of the Appointments Committee, Engineering Laboratory, Cambridge, to whom applications should be sent not later than 31st July, 1953. E9420

UNIVERSITY OF DURHAM

KING'S COLLEGE, NEWCASTLE UPON TYNE

DEPARTMENT OF CIVIL ENGINEERING

DEMONSTRATORSHIP IN CIVIL ENGINEERING

The Council of King's College invite applications for a DEMONSTRATORSHIP IN CIVIL ENGINEERING, for work in the drawing-office and laboratories. The appointment will be for a period of one year at a salary of £450 per annum. Duties to commence 1st October, 1953.

Applications, together with the names of three referees, should be submitted as early as possible to the undersigned.

G. R. HANSON,
E9394 Registrar of King's College,

UNIVERSITY OF NATAL

DEPARTMENT OF ELECTRICAL ENGINEERING

SENIOR LECTURER

Applications are invited for the post of SENIOR LECTURER (Heavy Current) in the Department of Electrical Engineering in Durban.

The successful applicant will be required to assume duty on February 1st, 1954.

The commencing annual emoluments, within the range £1200 to £1500 for married men or £1000 to £1300 for single men, will depend on qualifications and experience.

Further particulars and information as to the method of application should be obtained from the Secretary, Association of Universities of the British Commonwealth, 5, Gordon Square, London, W.C.1.

The closing date for the receipt of applications in London and South Africa is 31st August, 1953. E9336

PETERBOROUGH JOINT EDUCATION BOARD

PETERBOROUGH TECHNICAL COLLEGE

APPOINTMENT OF ASSISTANT IN ENGINEERING SUBJECTS, GRADE A

Applications are invited for the post of full-time ASSISTANT TEACHER, Grade A, to teach mechanical engineering subjects. Some teaching experience is desirable and salary will be in accordance with the conditions of the Burnham Technical Report.

Suitably qualified applicants may obtain further information and forms of application from the undersigned on receipt of a stamped, addressed foolscap envelope. Application should be made within fourteen days of the appearance of this advertisement.

LESLIE TAIT,
Chief Education Officer.

Education Offices,
Town Hall,
Peterborough. E9333

ROYAL AIRCRAFT ESTABLISHMENT TECHNICAL COLLEGE FARNBOROUGH, HANTS

DEMONSTRATORS IN MECHANICAL ENGINEERING

Farnborough, Hants, Royal Aircraft Establishment Technical College requires DEMONSTRATORS IN MECHANICAL ENGINEERING to assist in organisation, preparation and control of work to Final B.Sc. (Eng.) standard in materials, metallurgy, metrology, heat engines and aerodynamics laboratories. A little teaching may be involved. Facilities for research or further study may be available. Qualifications: Engineering Degree or equivalent, preferably with industrial experience. Salary on Burnham Scale for Assistants "A" plus £40 special addition and appropriate allowances, and subject to Teachers' Superannuation Acts. Details and forms from Principal, to whom forms must be returned within 14 days of this notice. E9367

PUBLIC APPOINTMENTS

UNIVERSITY OF NOTTINGHAM

ASSISTANT LECTURER IN CIVIL ENGINEERING

Applications are invited for the above appointment. Applicants should have a good Honours Degree and at least two years' practical experience. Initial salary within the scale £450 by £50 to £550, according to qualifications and experience.

Form of application and conditions of appointment may be obtained from the undersigned to whom applications should be sent as soon as possible.

H. PICKBOURNE,
E9363 Registrar.

HER MAJESTY'S COLONIAL SERVICE

LOCOMOTIVE SUPERINTENDENTS

The following vacancies exist for Mechanical Engineers in the Railway Department, Nigeria :—

ASSISTANT DISTRICT SUPERINTENDENT (LOCOMOTIVE) (CDE.110/14/010).

Duties include responsibility to the District Superintendent for the direction and efficient maintenance and working of the Locomotive Running Section. Appointment either pensionable or on contract at a fixed salary of £1735 per annum or £1930 per annum respectively. Candidates, not less than 35 years, must be A.M.I.Mech.E., must have served apprenticeship and pupilage in locomotive repair workshop with subsequent experience, and have had at least 10 years on administrative duties in locomotive running department. Drawing-office experience an advantage.

SENIOR ASSISTANT LOCOMOTIVE SUPERINTENDENT (CDE.110/14/04)

Duties include supervision of European and African staff and general administration in a district. Appointments will be pensionable on probation in scale £1400–£1560 per annum or on contract in the range £1656–£1898 per annum. Candidates between the ages of 32–40 should have served an apprenticeship and pupilage in a locomotive repair workshop and thereafter have had footplate and running shed experience, and at least 7 years on administrative duties in a locomotive running department. Candidates must be A.M.I.Mech.E. or be exempt from Parts A and B of the examination for Associate Membership and be prepared to obtain Corporate Membership during period of probation or contract.

On contract appointments a gratuity of £100–£150 per annum is payable on satisfactory completion of contract. Free first-class passages for officer and his wife and an annual maintenance allowance or free passage allowance up to £75 each is payable in respect of a maximum of two children. Furnished quarters available at rental charge of 10 per cent of basic salary. Leave is granted at rate of 7 days for each month of residential service after tour of 18–24 months.

Apply in writing to the Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, giving briefly age, qualifications and experience. Mention the reference number shown against the post applied for. E9403

GOLD COAST LOCAL CIVIL SERVICE

GOLD COAST RAILWAYS

CONSTRUCTION ENGINEER

Appointment is on contract in the Gold Coast Local Civil Service. Consolidated salary in the scale £1660 by £60 to £2020 per annum, plus gratuity, payable on satisfactory completion of contract, of £37 10s. for each completed three-month period of satisfactory service. Candidates must hold a recognised University Degree or Diploma in Civil Engineering carrying exemption from Sections I and II of the A.M.I.C.E. examinations or be A.M.I.C.E. They must have had at least ten years' experience in location and construction work, erection of steelwork for bridges and buildings, and also concrete works, such as station buildings, bridges and culverts. The officer appointed will be in charge of doubling the existing single railway line between Takoradi Junction and Tarhwa. He will be expected to do reconnaissance and locatory surveys for deviations, set out work, let and supervise contracts and carry out work departmentally where necessary. Full details on application.

Apply in writing to the Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, giving briefly age, qualifications and experience. Mention the reference number CDE 110/13/01. E9343

GOLD COAST LOCAL CIVIL SERVICE

GOLD COAST GOVERNMENT

ASSISTANT DIRECTOR OF PUBLIC WORKS

Appointment is on contract with salary in the consolidated scale £2190 by £60 to £2310 per annum. Gratuity is paid at the rate of £37 10s. for each completed three months' period of satisfactory service. Generous leave with free passages. Candidates must be Corporate Members of the Institution of Civil Engineers and have had at least 15 years' practical experience of civil engineering works allied with administrative control and direction.

Full particulars on application.

Apply in writing to the Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, giving briefly age, qualifications and experience. Mention the reference number CDE.112/13/09. E9402

PUBLIC APPOINTMENTS

CITY OF PORT ELIZABETH

VACANCY—SECOND GRADE ENGINEERING ASSISTANT (ROADS)

Applications are hereby invited for the position of SECOND GRADE ENGINEERING ASSISTANT (ROADS) in the City Engineer's Department in Grade 7 (£540 by £32 to £700), at an initial salary commensurate with experience and qualifications.

A cost-of-living allowance will be paid to the successful applicant at the rate of £176 16s. per annum for a single person and as follows for a married person, viz.:

At a salary below £600 per annum, £207; at a salary of £601 and above per annum, £230.

Applicants must possess a University Degree in Civil Engineering or be a Corporate Member of the Institution of Civil Engineers or hold the Testamur of the Institution of Municipal Engineers. They must have had experience in road construction and the construction of stormwater drains and sewers, and should have had experience in a Municipal Engineer's Department.

The appointment will be subject to the Council's conditions of service and leave regulations, and the successful applicant will be required to serve a probationary period of three months and pass a medical examination by the Council's Medical Officer of Health and become a member of the Municipal Pension Fund.

Applications, giving full details in regard to age, marital state, qualifications and experience, and accompanied by not more than three recent testimonials, will be received by the undersigned not later than 12 noon on Friday, the 24th July, 1953.

DAVIS AND SOPER, LTD.,
Agents to the City Council of Port Elizabeth.

52 and 54, St. Mary Axe,
London, E.C.3,
1st July, 1953. E9373

THE URBAN DISTRICT COUNCIL OF ABERDARE

ENGINEERING ASSISTANT, A.P.T. GRADE III

Applications are invited for the post of ENGINEERING ASSISTANT, A.P.T. Grade III (£525 per annum by £15 to £570 per annum).

Applicants should have had sound training in a municipal engineer's office; should have obtained a good general experience, and must have passed either the Intermediate Examination of the Institution of Municipal Engineers (Testamur) or Sections A and B of the Examination of the Institution of Civil Engineers.

The appointment will be subject to the National Joint Council conditions of service; to the provisions of the Local Government Superannuation Act, 1937; to the passing of a medical examination, and to termination by one month's notice on either side.

Applications, stating clearly the post for which application is being made, age, qualifications and experience, together with copies of two recent testimonials, must be delivered to me before noon on Saturday, 18th July, 1953.

D. G. JAMES,
Clerk of the Council.

Town Hall,
Aberdare,
3rd July, 1953. E9395

SUDAN GOVERNMENT

MINISTRY OF AGRICULTURE

FIELD ENGINEERS

The Ministry of Agriculture, Sudan Government, requires the services of two FIELD ENGINEERS (Mobile Plant) in the Engineering Division for the operation and maintenance of mobile earthworking equipment mainly of caterpillar manufacture.

Age limits 30–40, but suitable candidates outside these limits will be considered.

Appointment will be on short-term contract (with bonus), determinable by six months' notice on either side. Salary ranges from £E.800–£E.£1350. Starting rate of pay is fixed according to age, qualifications and experience.

An outfit allowance of £E.50 is payable when the contract is signed.

Cost-of-living allowance is payable on a sliding scale which varies with the cost-of-living indices.

There is at present no income tax in the Sudan.

Further particulars and application form will be sent on receipt of a postcard only addressed to the Sudan Agent in London, Sudan House, Cleveland Row, London, S.W.1, quoting "Field Engineer 431," and name and address in block letters. E9354

MINISTRY OF WORKS

STRUCTURAL ENGINEERING DRAUGHTSMEN

STRUCTURAL ENGINEERING DRAUGHTSMEN required in London, at Risley (Warrington), Harwell (near Didcot, Berks), and other provincial centres. Accommodation available for single men at Risley and Harwell.

London salary up to £628 per annum. Starting pay according to age, qualifications and experience. Rates outside London are slightly lower.

Applicants should be experienced in design and/or detailing of either reinforced concrete or structural steelwork. The work is varied and not confined to standard schemes. Reasonable prospects of promotion. Although these are not established posts, many have long-term possibilities and competitions are held periodically to fill established vacancies.

Write, stating age, nationality, experience and locality preferred, to Chief Structural Engineer, W.G. 10/S.2 Ministry of Works, Abell House, John Islip Street, London, S.W.1. E8832

PUBLIC APPOINTMENTS

GOVERNMENT OF QATAR

STATE ENGINEER'S OFFICE, DOHA, QATAR, PERSIAN GULF

APPOINTMENT OF DEVELOPMENT ENGINEER

Applications are invited from gentlemen of suit qualifications and experience for the above appointment.

A knowledge of the Middle East or Persian G is an advantage.

The duties will be as follows under the supervision of the State Engineer :—

(a) Co-ordination of development in the follo spheres :—
Civil engineering.
Architectural and building works.
Electrical engineering.
Mechanical engineering.
Water supply.
Port development.
(b) Control of the administrative side of the E neering departments, including the supervisio contracts, preparation of contract documents, of quantities, measuring up and monthly paym
(c) Material ordering for development projects.

The successful applicant will also be expected take over the duties of the State Engineer in the of sickness or leave.

Applicants should have had considerable ex ence in rapid development projects and should possess sound practical knowledge in the ma of spheres mentioned above.

Applicants should be between the ages of 32 an must be physically fit and should be able to sp Arabic.

Applications will be considered only from C porate Members of the following professio bodies :—
The Institution of Civil Engineers.
The Institution of Mechanical Engineers.
The Institution of Electrical Engineers.
The Institution of Municipal Engineers.
The Royal Institute of British Architects.

The salary offered is Rs. 2,500/– per Arabic mo tax free, payable in Qatar = (about £2280 per ann

Contracts offered are for five years, terminable three months' notice on either side. The first months' service is on probation.

Free furnished Government quarters will be p vided, but married applicants must be prepared an initial separation from their families for a pe of up to six months.

The following are provided free :—
(a) Air passages on joining, leave and termina
(b) Medical attention.
(c) Light and water.
(d) A car for official duties.

Leave is earned at the rate of 90 days per year may be taken after 18 months' service.

Applications, in duplicate, should be addres to the undersigned, care of C. Tennant, Sons Co., Ltd., 4, Copthall Avenue, London, E.C.2, should be clearly marked on the envelope "Devel ment Engineer—Government of Qatar."

The closing date for the receipt of applicatio 31st August, 1953.

H. T. HALE, T.D. (B.Sc.Eng.), A.M.I.C.E.
State Engineer
to the Government of Qatar.

Doha, Qatar,
24th June, 1953. E93

COUNTY COUNCIL OF ESSEX

ARCHITECT'S DEPARTMENT

SENIOR ASSISTANT HEATING ENGINEER, GRADE VI

SENIOR ASSISTANT HEATING ENGINEE Grade VI, on established staff. Salary not exceed £735.

Candidates should be members of I.H. and V Work includes schools, colleges and other co buildings.

Application forms from H. Conolly, F.R.I.B.A County Architect, County Hall, Chelmsford, retu able with copies of three recent testimonials, by 1 July, 1953.

Canvassing disqualifies. E94

COLONIAL DEVELOPMENT CORPORATION

ELECTRICAL ENGINEER

ELECTRICAL ENGINEER required by Colo Development Corporation for mining project o seas; A.M.I.E.E. or similar qualification prefer Experience in erection and maintenance of po stations, transmission lines, switchgear and mo desirable. Salary according to qualifications experience, plus allowances. Contributory pens scheme. Two-year tour with four months' le Free passages and accommodation.

Applicants to apply in writing to Personnel, Hill Street, W.1, giving details of age, experience qualifications, quoting Serial No. 180. E93

KING'S COLLEGE HOSPITAL

CHIEF ENGINEER'S DEPARTMENT

ENGINEERING DRAUGHTSMAN

Applications are invited for the post of ENG NEERING DRAUGHTSMAN in the Chief E neer's Department. The salary, dependent on and qualifications, is in the range £360 by £20 one £25 to £545, plus London weighting.

Applicants must have experience in drawing-o procedure and practice. The Ordinary Nation Certificate in Mechanical Engineering or the equ valent would be an advantage.

Applications, stating age, education and exp ence, together with the name of two referees, sho be sent to the Chief Engineer not later than 25th J 1953. E93

THE ENGINEER

JULY 10, 1953

The British Coal Utilisation Research Association Annual Report

THE British Coal Utilisation Research Association has issued its annual report for 1952, a year which marked the end of the Association's third quinquennium, and the report includes a statement of finance during the period, a brief review of the programme of research carried out, and a broad consideration of the next five-year period. In the survey of research progress, the proving of the method developed for aggregating slurry and other low-grade materials is noted and mention is made of the effort to devise a central heating system using a small-bore pipe and a pump unit. Progress is reported towards a method of assessing the fluctuating dust burden of flue gases and the survey mentions the designing of a cyclone combustor for low-grade fine coals, which is linked with the effort to develop a coal-fired gas turbine. Early difficulties, it is stated, have been overcome and the remaining major objective is to produce combustion gases having the minimum tendency to form deposits. Field studies of gas producer practice have been concerned with solving the problem of tar deposition in the mains and of maintaining a level bed in producers by mechanical means, while the survey states that future work will be directed to obtaining gas of higher calorific value. A "dewpoint meter," developed by the Association, is now being manufactured and marketed and the report instances chemical studies of coal structure and of solvent techniques, together with studies of smoke formation and repression. A method is described of pretreating bituminous coal chemically to reduce the smoke formed during combustion; although, at present, only of academic interest it is hoped to apply the method on a technical basis. The report gives details of domestic and industrial research with sections devoted to boilers, furnaces and gas producers, and also laboratory research which is divided into four parts dealing with combustion, physics, mathematics and chemistry. Reports and published papers are listed and briefly summarised, patents held by the Association are noted and the report includes the details of the various committees, a list of the research staff and a list of members.

Fluoridation of Domestic Water Supplies

THE report of the United Kingdom Mission on the Fluoridation of Domestic Water Supplies in North America as a Means of Controlling Dental Caries was published yesterday, Thursday, July 9th, as a White Paper, by Her Majesty's Stationery Office. From the evidence obtained the mission states, in the report, that it is satisfied that fluoridation is a useful means of reducing the incidence of dental decay and would be useful in this country, but before studies can be started in this country the mission feels it will be necessary to ascertain the incidence of dental caries and to assess the amount of fluoride to be added to the water. The amount indicated is one part per million and it will be also necessary to provide adequate safeguards against errors in dosage. Although the evidence of the harmlessness of fluoride is almost conclusive, the report considers that research should be encouraged into the effect of the continued use of water containing a low level of fluoride on health and disease. Another point mentioned is the investigation into simple methods of adding fluorides to water obtained from wells and springs. Artificially fluorided water is considered similar in its action to water containing natural fluorides and the report goes on to state that the possible development of mild mottling of the teeth is not a hazard. However, it is emphasised in the report that fluoridation is not a cure for dental caries nor does it necessarily retard progress of existing caries and that there is no evidence that consumption of water of low fluoride content would endanger health. The mission states that it discovered no evidence to indicate that fluoridated water affected adversely industrial processes.

Fire Research 1952

THE annual report of the Fire Research Board and the report of the Director of Fire Research for the year was published last week. The Director's report is in two parts, the first being a report for 1952, and the second a survey of the first six years' work of the Joint Fire Research Organisation which began in 1947 at the Fire Testing Station. It is estimated in the report that at least two out of three fires which break out in buildings are due to carelessness and could be avoided. More than 42,000 fires take place in buildings each year, and during a four-year period (1946–50) one in every four was caused by fires or radiators. Although nearly one fire in six was associated with electricity, the report points out that the majority of fires caused by electrical equipment may be due to misuse of the equipment. The annual incidence of fires caused by wireless sets during the years 1947–1951 remained at the average of 1 to 40,000 approximately. The incidence for television sets decreased considerably during the same years—from 6·4 fires per 10,000 sets in 1947 to 1 per 10,000 sets in 1951. The report refers to the systematic study of the behaviour of prestressed concrete in fires being made at the Fire Research Station. It was found that the time taken to bring about failure of a beam is mainly dependent on the temperature of the stressed cable and that a concrete cover of 2½in over the cable gives a fire-resistance of two hours before the beam collapses. The failure, when it comes, is not sudden and a fireman would have ample warning before the collapse of the beam. It was reported last year that the study of the spread of fire in buildings could be done satisfactorily by using small models, and some interesting work has been carried out. The experiments have shown that a combustible wall board that has received fire-retardent treatment first behaves like an incombustible material, but later burns like an untreated material. The results emphasise the important difference between the requirements for limiting the surface spread of flame and those for complete fire resistance. Work in hand on fire extinction included experiments with water sprays.

Building Research

THE second report of the Ministry of Works Advisory Council on Building Research and Development, which has just been published, deals with the work of the council from 1949 to 1952. This council each year surveys the entire known programme of building research in the United Kingdom, and in the present report the preparation of this programme is described, as is the method of obtaining the views of the bodies representing the industry. The report also gives the council's main comments and recommendations as a result of its scrutiny of the programmes for 1951–52 and 1952–53. The three main sections of the report deal with organisation and cost of building research, current building research, application of results of research and the conclusions reached on work since 1949. It is estimated that during one financial year some £700,000 of public money is spent on building research and the publicising of the findings for the benefit of the building trade and allied branches of civil engineering.

Progress of Tin Research in 1952

THE annual report of the Tin Research Institute, Greenford, Middlesex, which was published last week, states that the various groups of tin producers who provide the funds have unanimously agreed to increase their contributions by 50 per cent in order to strengthen the Institute's staff and especially to increase its free technical services to industry in the chief tin-consuming countries of the world. The tin-producing countries supporting the Institute are the Belgian Congo, Bolivia, Indo-China, Indonesia, Malaya and Nigeria. Following this additional grant, information centres were opened in Canada, France, Italy and Sweden; centres already existed in Belgium, Holland and the United States. Mention is made in the report of a number of applications of tin which originated from research at the Institute. Certain difficulties have been experienced with the decorative tin-nickel electro-plate for the first two years, but a suitable filtering medium has now been found. Tin-zinc electro-plate, a corrosion-resistant coating, has found many further uses in the radio, motor-car and aircraft industries. There is work going forward on improved aluminium-tin bearing alloys; their extra hardness as compared with tin-base Babbitt alloys will, it is expected, enable these alloys to recapture for tin some of the market now held by copper-lead and other high-duty bearings. Research on tinplate has been concerned largely with the quality of the tin coating on both the hot-dipped and electrolytic types. A satisfactory economical method of producing electrolytic tinplate in the laboratory has been installed and this permits close study of each of the various stages of manufacture.

New Rolling Stock for British Railways

IT is announced that during the current year British Railways will build 288 locomotives, 1448 carriages and 42,641 wagons providing its full allocation of materials is received. The programme includes locomotives and rolling stock authorised during previous years but not built owing to shortage of materials, together with part of the normal 1953 programme of construction. The 288 locomotives will include 209 steam, one diesel-electric main line, fifty-one diesel-electric shunters of the new standard type, fourteen diesel-mechanical shunters and thirteen electric locomotives for the Manchester-Sheffield-Wath services. Of the steam locomotives, 150 will be of new standard designs and fifty-nine of existing regional types. Included in the standard locomotives will be the first ten of a new 2–10–0 class "9"—the most powerful locomotive yet designed by British Railways and the first standard type to be designed exclusively for heavy freight traffic. Most of the carriages will be of the new standard all-steel designs, but 292 will be of regional non-corridor design, for which much of the material is already in hand. Under the wagon building programme there will be provided 1200 wagons, of capacities ranging from 12 tons to 42 tons, for carrying the large quantities of steel now being produced. There will also be 113 wagons ranging from 12 tons to 135 tons capacities for special kinds of traffic, and 2324 wagons with shock-absorbing gear. Some 25 per cent of all the wagons, including most of the general merchandise wagons, will be fitted with vacuum brakes to enable them to run in express freight services.

Present-Day Locomotive Working in Great Britain*

No. IX.—THE "KING" CLASS 4-6-0s OF THE FORMER G.W.R.—Part I.

By O. S. NOCK, B.Sc., M.I.C.E., M.I.Mech.E.

At the time of its introduction, in 1927, the "King" class was the most powerful express passenger locomotive in Great Britain. Since then many classes of "Pacific" with large boilers have been put into service, though none having a nominal tractive effort greatly in excess of the "Kings." At the present time the working of the "Kings," with their narrow fireboxes, is of particular interest, and in this article and a succeeding one the author analyses his post-war experiences both in general travelling and on the footplate.

NOT long ago an enthusiastic young Cockney fireman remarked: "If our 'Kings' had been built to-day instead of twenty-five years ago they'd have caused a sensation!" It was a characteristic piece of engine-house backchat, meant none the less seriously, but it set me analysing once again the proportions of these engines. In most branches of engineering it is considered good practice to aim at a high power/weight ratio, and if the argument of that young fireman had been followed out we should see the "King" class engine emerging into a railway world where all British locomotives of class "8" capacity were of the "Pacific" type, and had nominal tractive efforts rising from the 35,455 lb of the Gresley stream-lined "A4" to the 40,430 lb of the Peppercorn "A2." The weight of the engine alone ranged from the 92·5 tons of a Southern "Merchant Navy" to the 105·3 tons of an L.M. "Duchess." The "King," with a nominal tractive effort of 40,300 lb is not a "Pacific" at all, but a 4–6–0, with a total engine weight of 89 tons. But the boiler of the "King" is relatively small, and the narrow firebox has a grate area of 34·3 square feet, against the wide grates of all the "Pacifics," with areas ranging from 41·3 square feet to 50 square feet.

At the time the "Kings" were built it was usually possible to use selected grades of soft Welsh coal on the crack turns, and the locomotives showed up well in the haulage of heavy trains on long non-stop runs to and from the West of England. On shorter start-to-stop runs, in the course of daily round trips from Wolverhampton to Paddington and back, one could often record the output of high drawbar horsepower for short periods on the stiff gradients encountered. When it comes to the use of inferior fuels the wide, shallow firebox is generally considered to give the firemen a better chance of maintaining steam pressure. But as long ago as 1906 Mr. Churchward presented before the Institution of Mechanical Engineers a critical analysis of many large locomotive boilers then in use, both in this country and America. Obviously he had made a close study of the wide firebox and gave it as his opinion that, other things being equal, the wide firebox was more difficult to fire than a narrow one, owing to the skill needed to keep the large grate evenly covered. There is a tendency, too, to lay the whole performance of the engine upon the proportions of the boiler and firebox, whereas recent work on the stationary testing plants in this country has shown what vital differences may be caused by apparently small adjustments in the critical dimensions of the "front end."

To me, as a regular traveller on the Western Region, and one who has had the privilege of supplementing observations from the carriage by some 1600 miles of travel since the war on the footplate of "Kings," it has been very interesting to record the post-war running of these engines, since the experience of the years 1947–1952 provides something towards answering a vital question: how this design, of unique proportions and 1927 vintage, is standing up to the running conditions of to-day. Before coming to an analysis of post-war experiences, a brief reference is needed to the work the "Kings" performed between 1927 and 1939. In all probability the hardest task was the running of the down Cornish Riviera Express during the late autumn each year, and during the spring, when three slip portions were carried and the loading of this full train was a maximum. At first the famous non-stop run from Paddington to Plymouth was operated, and then the sectional time was thus:—

Section	Load (gross tons)	Distance, miles	Booked time, min.	Speed, m.p.h.
Paddington-Westbury ...	530	95·6*	96	59·7
Westbury-Taunton ...	450	47·3*	48½	58·6
Taunton-Exeter	385	30·8	30	61·6
Exeter-Plymouth	310	52·0	65½	47·6

*Via Westbury and Frome Stations. By-pass lines not then constructed.

The successive reductions of the load were balanced by the increasing severity of the running conditions, not only in gradients, but in curvature of the line, which precluded anything in the way of sustained high speed west of Exeter. Above all the run had to be made non-stop. On one recent occasion I heard the remark: "What a difference it would make if we could stop for five minutes, with a couple of lads on the tender getting coal forward!"

Difficulty or not, the "Kings" established a high standard of performance on the West of England and Wolverhampton trains, and brief reference to three actual journeys will show that the above schedule and loadings did not by any means represent the limit of their capacity. The first two runs were made on the Cornish Riviera Express at times when holiday loadings required division of the train, and the third was made on one of the "up" West of England expresses, running non-stop from Exeter to Paddington.

Since the war one of the most interesting developments at Swindon has been the fitting of a number of "King" class engines with new boilers having a high degree of superheat. The altered dimensions can be studied from the accompanying Table I, while in some dynamometer car trials conducted in the autumn of 1948 the first engine to be so modified, No. 6022, showed a high standard of performance.

From my records of regular travelling on the Western Region main lines since 1946, at all times, and in all conditions of weather, a reasonably good general impression of the working efficiency of the "King" class engines under post-war conditions may be obtained. Excluding night trains, the

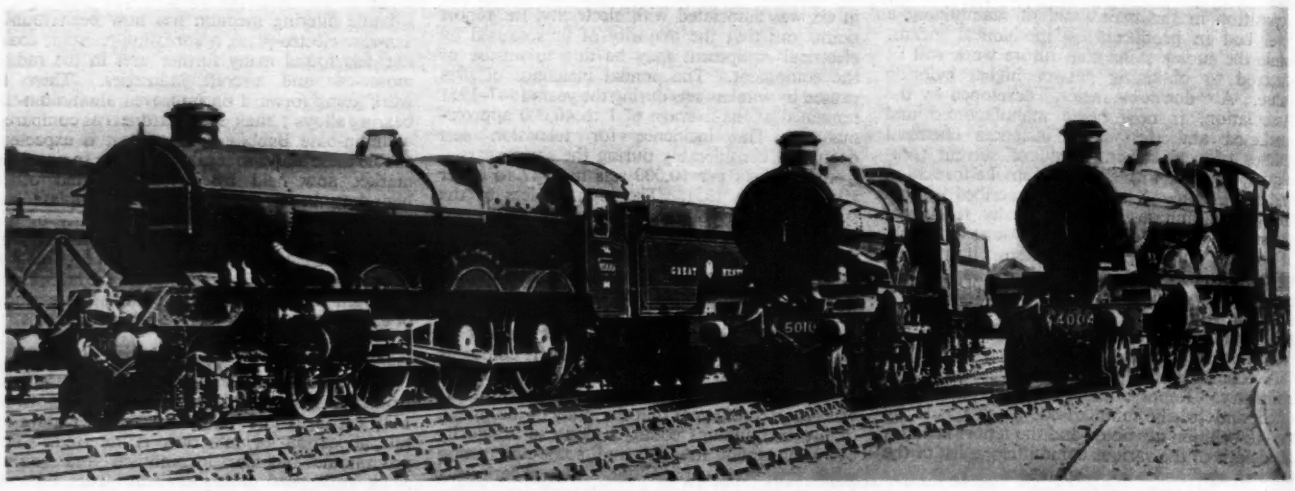


Fig. 1—Development of G.W.R. Locomotive Design (Reading Right to Left: "Star," "Castle" and "King" Class Engines)

* Previous articles in this series were: No. I, "The L.N.E.R. 2–6–2 'Green Arrow' Class." October 11, 1946; No. II, "The L.M.S.R. 'Coronation' Class 'Pacifics,'" December 13 and 20, 1946; No. III "The G.W.R. Oil-Fired 4–6–0s," February 6 and 13, 1948; No. IV, "The Mixed Traffic 4–6–0s." November 4, 11, 18 and 25, 1949; No. V, "The Western Region 'Castle' Class." April 20 and 27, 1951; No. VI, "First Results from the 'Britannias'" April 4, 1952; No. VII, "The Gresley 'Pacifics' on the East Coast Route." July 18 and 25, 1952. No. VIII, "The Thompson and Peppercorn Pacifics of the Former L.N.E.R.," May 29 and June 5, 1953.

FIRST RUN: *Engine No. 6028, "King Henry II"**

Section	Load, gross tons	Distance, miles	Booked time, min	Actual time, min	Actual speed, miles
Paddington-Reading	555	36·0	36	36½	59·2
Reading-Savernake	555	34·1	35	33½	62·2
Savernake-Westbury	555	25·5	23	21½	72·0
Westbury-Castle Cary	440	19·8	22	19½	60·0
Castle Cary-Cogload Junction	440	22·5	21	20½	66·7
Cogload-Taunton	440	5·0	4½	9½†	—
Taunton-Exeter	440	30·8	30	32†	56·3

* Engine later renamed "King George VI." † Heavy slacks for permanent way repairs
Net time to passing Exeter, 173·7 miles, 166 min.

SECOND RUN:

Engine, 6016, "King Edward V": load 440 tons to Exeter, passed Heywood Road Junction, 94·6 miles, in 88½ min. Later, with 405 tons, ran from Exeter to Plymouth, start to stop 52 miles in 69½ min.

THIRD RUN:

Engine, 6022, "King Edward III": Load 575 tons. Ran Exeter to Paddington, 173·5 miles, via Frome and Westbury by-pass lines in 177½ min, or 174 min net. Maximum speed on level track, 76 m.p.h.

timings of which are relatively easy and on which I have noted time to be kept (or, on occasions of delay, substantial amounts of time to be regained) I have detailed notes of sixty-nine long-distance journeys made between September, 1946, and November, 1952, and on only two occasions could any time be booked against the engine. There was a third occasion, on which the engine failed and had to be removed from the train. This, however, occurred during the "glacial" period in the early months of 1947 on a day when snow had disrupted all the normal workings. No. 6018 was put on to the 4.15 p.m. from Paddington as a last resource, long after the train was due to depart, and it was eventually replaced by another engine at Swindon. The sixty-nine other journeys cover 8090 miles of travel, and of the thirty engines of the "King" class all but seven figure in one or more of my journeys. The longer distance runs of which I have a number over the same route are analysed in Table II.

The above average net times represent a total net gain on schedule of 207 min, but they also include the only two cases of loss of time. Curiously enough, these were both with the same engine, No. 6019, though under quite different conditions. The first case on the 3.30 p.m. from Paddington to Taunton, booked in 148 min start to stop, was unaccountable, as the engine appeared to be in good order and steaming well. It seemed nothing more than a misjudgment on the part of the driver. Nevertheless 2 min were lost; but in the second instance the engine had run more than 91,000 miles since last general overhaul and was due for the shops. Evidently the record of performance at Old Oak shed showed that the engine was still reliable for express passenger duty, and in the morning of the particular day it worked the 8.28 a.m. Chippenham to Paddington and gained 5 min on schedule. On the same evening, however, the heavy and fast 6.30 p.m. down was too much for the engine, and with a load of 465 tons, 2 min were lost, although one of these lost minutes was regained between Chippenham and Bath. The 6.30 p.m. is a hard train to work, with its allowance of 82 min to pass Swindon, 77·3 miles, against the gradually rising nature of the road. The average performance of "King" class engines, as shown by the details of the twelve runs I have personally observed, is analysed in the accompanying table.

It should be emphasised that the above are average figures for all runs observed. Some individual runs were very much finer. Engine No. 6018, for example, with 485 tons, following signal delays in the early stages, averaged 64 m.p.h. from Didcot to Swindon, and 68·2 m.p.h. onwards to Milepost 92. On this occasion the drawbar horsepower between Didcot and Swindon was 1172. On another run, the first of the high superheat engines, No. 6022, hauling a 450-ton load, passed Swindon (77·3 miles) in 76½ min from the dead start at Paddington. On this turn the engine works through to Plymouth; the London men, who return with a fast freight train, are relieved at Bristol, and the engines are in common-user duty. It was unfamiliarity with the individual engine that caused loss of time on one journey with No. 6019, when that locomotive had a mileage of 91,000 since last overhaul. The two minutes were lost between Paddington and Slough

TABLE I—*"King" Class Locomotives: Leading Dimensions.*

	Original design	High superheat
Cylinders: four, diameter by stroke, inches	16½×28	16½×28
Motion:		
Piston valves, inches	9	9
Steam lap, inches	1¼	1¼
Valve travel (max.), inches	7½	7½
Driving wheels, diameter	6ft 6in	6ft 6in
Boiler pressure, lb per square inch	250	250
Distance between tube-plates	16ft 5in	16ft 5in
Heating surfaces:		
Firebox, square feet	193·5	194·5
Tubes, square feet	1,655·5	1,114·0
Flues, square feet	352·0	704·0
Total evaporation, square feet	2,201·0	2,012·5
Superheater:		
No. of elements	16	32
Heating surface, square feet	289	489
Grate area, square feet	34·3	34·3
Nominal tractive effort at 85 per cent boiler pressure	40,300 lb	40,300 lb

TABLE II—*Analysis of Longer Runs with "King" Class Engines*

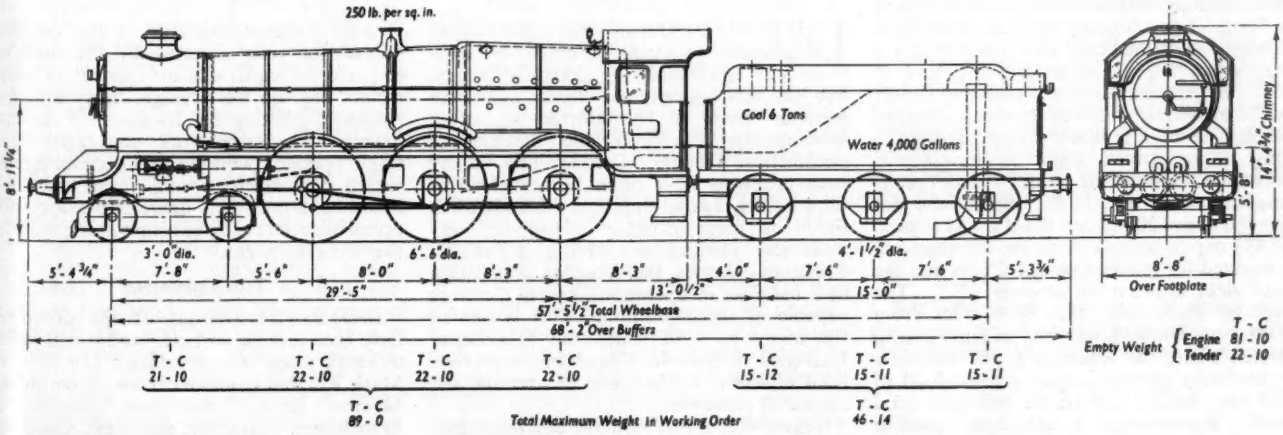
Route and train	No. of runs	Average load, tons gross	Mileage	Booked time	Average net time, min	Net average speed, m.p.h.
8.28 a.m. Chippenham-Paddington	11	418/380§	94·0	102	97	58·2
9.21 a.m. Bath-Paddington	7	413	106·9	119	112½	57·0
5 p.m. Paddington-Bath†	2	450	106·9	120	115	55·8
Paddington-Bath non-stop	10	401	106·9	114	110	58·4
6.30 p.m. Paddington-Chippenham	12	451	94·0	99	97½	58·0
Paddington-Taunton non-stop‡	7	409	142·7	*	145	59·1

* Various timings between 144 min and 154 min.
† Runs prior to acceleration of train.
‡ Includes two runs on Cornish Riviera Express passing Taunton.
§ Load reduced by slip coach at Didcot.

TABLE III—6.30 *p.m., Paddington to Chippenham: "King" Class Engines: Average Load* 451 *tons.*

Miles, point to point	Section	Booked time, min	Average net time, min	Average speed, m.p.h.	Average gradient	Assumed train resistance, lb per ton	Average d.h.p.
18·5	Paddington-Slough	22	23	—	—	—	—
34·6	Slough-Didcot	35½	34	61·1	1 in 2220 rising	10·2	842
24·2	Didcot-Swindon	24½	24	60·5	1 in 875 rising	10·0	976
14·7	Swindon-Milepost 92*	—	13½	65·5	1 in 470 falling	11·0	389

* Usual point of shutting off steam.



Four cylinders:
diameter ... 16½in
Stroke ... 28in

Wheels:
Bogie, diameter ... 3ft
Coupled, diameter ... 6ft 6in
Tender, diameter ... 4ft 1½in

Tractive effort ... 40,300 lb

Fig. 2—"King" Class Locomotive

while the driver was taking the measure of the engine and judging to what extent he could "push" her on this hard booking. No further time was lost after Slough, with a load of 465 tons.

The runs analysed in Table II cover forty-nine out of the total of sixty-nine journeys observed. The remaining twenty include some of the most striking performances of all, apart from those I was privileged to make on the footplate. Before coming to the footplate journeys, which cover 1583 miles of travel, and the work of eight different engines, brief reference is needed to three runs of special merit and to the capacity of the "King" class engines in starting heavy trains from rest. The three runs were :

(*a*) 7.50 a.m. Leeds to King's Cross (Interchange Trials) ... ... Engine 6018
(*b*) Up "Dutchman" : Westbury to Paddington Engine 6010
(*c*) Up Cornish Riviera Express, Plymouth to Paddington... ... ... Engine 6022

I was a passenger on the last "King" run up from Leeds during the interchange trials of 1948, and noted some very sound work. From my familiarity with East Coast running over a period of twenty years prior to those trials one of the most impressive features of the journey was the evidence of how the Old Oak driver had mastered the characteristics of that road, and handled his train with the ease and competence of a native. The following details are taken from the report of the Locomotive Testing Committee of the Railway Executive :—

Length of trip	185·8 miles
Total journey time	264½ min.
Total running time	232½ min.
Total time under power	197 min.
Average speed	47·9 m.p.h.
Average d.h.p.	712
Coal consumed per train-mile	43 lb
Coal per d.h.p. hour	3·42 lb
Water consumed per train-mile	39·8 gall.
Evaporation, lb water per lb coal	9·24 lb
Gross calorific value of coal	13,793 B.Th.U. per lb

The various stages of the run can be summarised as in Table IV.

In all the engine gained 8½ min on booked time, and this was achieved by clean brisk starts from each stopping station and good hill climbing. On falling gradients where high speeds are often attained by the ordinary East Coast expresses speed was moderate, often running without steam, with time well in hand. For a journey making intermittent demands upon the boiler the evaporation was very good, 9·24 lb of water per pound of coal. By running faster downhill and slower on the adverse stretches the coal consumption might have been reduced, though during the long rising stretch from Biggleswade to Stevenage, concluding with 5 miles continuously at 1 in 200 the engine was not worked above 20 per cent cut-off. At a speed of 48½ m.p.h. on this climb the drawbar pull (corrected for gradient) was 4·2 tons and the equivalent drawbar horsepower 1212. The average speed over the 54·9 miles from Yaxley to Hatfield was 58½ m.p.h., over a stretch where the tendency of the gradients is decidedly adverse ; with a gross load of 535 tons behind the tender this was good work, representing a calculated average drawbar horsepower of 1010 throughout.

In ordinary service over the West of England, main line engine No. 6010, "King Charles I," put up a very similar performance with an identical load. It was a day of Newbury Races, and the 8.30 a.m. from Plymouth to Paddington was scheduled to make an additional stop at the Racecourse station. In consequence harder running than usual was made to offset the loss in time occasioned by the stop. From Westbury the train was started well, on the level, despite drizzling rain, passing Edington, 4·2 miles, in 7 min at 53 m.p.h. Thereafter the 21·3 adverse miles to Savernake, gradient averaging 1 in 450, were climbed at an average speed of 52½ m.p.h., representing an output of 1150 d.h.p. to 1200 d.h.p. continuously. No high speeds were run downhill, and after Reading, where the load was reduced, by the detaching of a slip portion, from 535 tons to 465 tons, the maximum speed on level track was 66 m.p.h. Net time (allowing for the extra stop and for time lost by various signal checks) was 102 min for the run of 95·6 miles—an average speed of 56·5 m.p.h. This run was made in the autumn of 1950.

The third run was interesting, in that pre-war Cornish Riviera average speed was attained, but with very much lower speeds on the favourable stretches. Severe slacks for engineering work were in operation at Long Sutton, Hungerford and Midgham, and the engine was worked harder than normal to get time in hand to offset the effect of the checks. In Table V comparison is made with a journey of 1935, though there is a significant difference in that this latter trip included a stop at Exeter, whereas the 1952 run was non-stop from Plymouth to Paddington. There was therefore no opportunity for getting coal forward while standing or taking advantage of the brief respite in any other way.

TABLE IV—*Leeds to King's Cross Run During Interchange Trials*, 1948

Stage	Miles	Actual time, min.	Average speed, m.p.h.	Load, tons gross	Max. speed, m.p.h.
Leeds-Holbeck	0·5	2¾	11·0	315	—
Holbeck-Wakefield	9·4	20½*	26·5	315	46
Wakefield-Doncaster	19·9	26½	45·0	460	66
Doncaster-Retford...	17·4	22½	46·4	490	64½
Retford-Grantham	33·1	39½	50·0	495	68½
Grantham-King's Cross	105·5	121†	52·3	535	71

* Includes signal stop, 1¼ min. † Includes signal check and permanent way slack.

TABLE V—*Cornish Riviera Express*

	Exeter to Paddington	
Year	1935	1952
Engine No.	6007	6022*
Load (gross tons behind tender) ...	390	360
Overall time : for 173·5 miles... ...	171¼	179¾†
Net time	169¼	169
Maximum speed, m.p.h.	83½	76
	Average speeds	
Stoke Canon to Whiteball Box, 16·4 miles : 1 in 285 rising	51·9	56·2
Somerton to Brewham Box, 17·3 miles: 1 in 400 rising	58·5	60·3
Edington to Savernake, 21·3 miles : 1 in 450 rising	59·9	65·3

* High superheat engine.
† Time from passing through at 30 m.p.h.

The 1935 journey included some long spells of sustained fast running, such as 76 m.p.h. over the 19 miles from Wellington to Curry Rivel Junction, and 74·8 m.p.h over the 18·6 miles from Kintbury to Calcot signalbox. On the 1952 journey, apart from a brief maximum of 76 m.p.h. on the Wellington bank, speed did not exceed 71 m.p.h. anywhere on the long downhill stretches. This post-war journey was made on a day of extremely bad weather, with torrential rain throughout from Exeter to Reading. The coal was of poor quality, yet on arrival at Paddington the enginemen reported first-class steaming throughout.

(To be concluded)

The Solution of Differential Equations on an Electronic Digital Computer

By C. F. GRADWELL, M.A.

Electronic digital computers can save very considerable time in the numerical solution of differential equations. The example considered in this article is concerned with the ballooning of cotton yarn which affects the air drag in ring and cap spinning, and becomes a limiting factor at high rotational speeds. In this investigation, using the Manchester Universal Electronic Computer, the time required to solve the equations for one set of parameters was thirty minutes, or about one-third of one per cent of the time needed by a single operator working with a desk machine.

DIFFERENTIAL equations arise in many practical problems. Sometimes solutions may be obtained by analytical means, but in the majority of cases numerical methods have to be resorted to, often necessitating a considerable amount of arithmetical labour. Consequently, many such problems have often been shelved in the past, or, again, empirical methods used, often at great expense. However, any numerical method of solving differential equations involves the repeated application of a basic set of operations, and is therefore capable of mechanisation. This is one of the many ways in which the Manchester Universal Electronic Computer can prove itself of service in the realm of scientific and industrial research.

This article shows how the computer may be used to solve sets of simultaneous differential equations of any order, and gives a particular example which is of importance in the cotton industry. The saving of time is very considerable, and in the example quoted the time required by the machine to solve the equations for one set of parameters was, on the average, thirty minutes, including printing the results to 5 decimal figures. The same work performed by a single operator working to 3 decimal figures with a desk machine would have taken 160 hours or more. This figure is based on the actual time taken by two operators, namely, two working weeks.

THE COMPUTER

General.—Descriptions of the computer have been given elsewhere,[1] and it will suffice to recall a few relevant data. The Ferranti Mark I digital computer, constructed at the Moston factory, and now installed at Manchester University, was built round the high-speed cathode ray tube memory device of Professor F. C. Williams and Dr. T. Kilburn. Without going into the details of this system, we may say that the face of a

single cathode ray tube (c.r.t.) may be arranged to hold sixty-four lines, each of twenty pairs of dots. Each pair of dots stores one binary digit, i.e. a nought or a one, so that a single tube contains 1280 binary digits. The time of access to this store is one *X*-sweep time, i.e. 240 microseconds.

At present there are eight such c.r.t. stores, which constitute the high-speed memory of the machine. The main store, however, consists of the magnetic surface of a drum revolving on a vertical axis at 2000 r.p.m., a binary digit being represented by the direction of magnetisation. On the surface of this drum are 256 " tracks," each track holding the equivalent of two c.r.t. stores. Thus, a whole drum may contain about 650,000 binary digits. Binary information, i.e. series of binary digits, may be transferred to or from the drum in blocks equivalent to either one, or two, c.r.t. stores by means of a series of 256 reading and writing heads suitably arranged round the surface of the drum. A transfer of information in either direction occupies about 30 milliseconds. All calculation is done from the electronic, i.e. c.r.t. stores, the average duration of one arithmetical operation, e.g. addition, being about 1 millisecond.

Since the machine has a memory device for holding binary digits only, it is convenient to use binary scale working throughout. However, the conversion from and to decimal numbers is quite easily performed by the machine itself. The standard length of a binary number in the machine is 40 digits, actually two consecutive lines of 20 each, which may be used to represent either all the positive integers from 0 to $2^{40}-1$, or, alternatively, all the integers from -2^{39} to $2^{39}-1$ inclusive. Note that since 40 binary digits are roughly equivalent to 12 decimal digits, the standard length of a working number affords ample accuracy in most problems. To make the best use of all the 40 binary digits a number is usually represented in the machine by a scaled up version of itself. Thus, the number π might be represented by $2^{38}\times\pi$, since this is the highest binary multiple of π which is less than 2^{40}.

Input.—Numerical data and working instructions are fed into the machine normally on teleprinter tape, one character at a time, a character consisting of 5 binary digits (a " 1 " being denoted by a hole). The 5 digits are read simultaneously by photoelectric means at a speed of about 250 characters per second.

Output.—The results of the machine's computations are fed normally to a standard teleprinter (speed 7 characters per second), or, alternatively, to a punch (speed 15 characters per second), if we wish the results to be punched on tape so that they may be fed back into the machine at a later stage.

The Console.—The console has two main functions. First, it possesses six monitor tubes in which the user can see displayed the contents of any of the c.r.t. stores simultaneously, and also the contents of the accumulator, multiplicand, multiplier, &c. This monitoring facility is very valuable when searching for programming errors. (The term " programming " is explained in the next section.) Secondly, the console houses all the switches necessary to the working of the machine. They include two rows of each 20 switches enabling the operator to write any desired group of 20 binary digits into the c.r.t. store, or to carry out any desired magnetic transfer. It must be emphasised, however, that these switches are not used during normal computation. They might be used, for example, to make a provisional correction to a known fault in a programme, or, again, to start off a calculation, by first bringing down the track on which the " programme " has been written to one of the c.r.t. stores.

Programming

The technique of presenting a problem in a form understandable by the machine is called " programming," a programme consisting of a series of " instructions." Each instruction is represented in the machine by a group of 20 binary digits, and consists essentially of two parts—a " function " part and an " address " part, e.g. if the function part says " add into the accumulator " and the address part is " 16," the effect will be to add the number in storage line 16 to the number already in the accumulator. A whole sequence of instructions to carry out some standard operation, e.g. finding a square root, is called a " library routine " and stored once for all on the drum on some particular track. Hence, the task of the programmer is to break his problem down into elementary arithmetic operations (such as addition, multiplication, &c.) for which he writes individual instructions, and certain standard operations (e.g. division) for which he calls in a library routine.

The usual technique is to split long programmes up into units of length corresponding to exactly one or two tubes, and to keep each section in the first two tubes while operative. When another section is required, it is called in from the magnetic store and replaces the previous contents of these tubes. The other six tubes are used for constants, working space and also for a sequence of instructions linking together the various parts of a programme.

A routine of particular importance is the " input routine." This routine causes tape to be read in until one of a certain number of " warning characters " is reached, all others being ignored. What happens after this depends on the particular warning character. There are, for example, warning characters to write in exactly one tube full of information, or to write a number into a particular store line, or again to transfer the contents of a c.r.t. store to a particular track of the magnetic drum.

Normally, instructions are written down in the order in which they are obeyed. Broadly speaking, there are four groups of instructions (excluding those relating to transfers to or from the drum) :

A, simple transfer of numbers, e.g. from a store line to the accumulator.

B, arithmetic operations, e.g. addition, multiplication.

C, logical operations (conjunction, disjunction, non-equivalence).

D, transfer of control. (1) Unconditional: next instruction to be obeyed is not the next one in the list, but some other specified one. (2) Conditional: for example, if the accumulator is zero or positive transfer control as in *D* (1), otherwise obey the next instruction.

A particularly useful facility is provided by the eight so-called *B*-lines, each of which consists of 20 binary digits. Every electronic instruction must specify one of the eight *B*-lines. The effect is that the contents of that *B*-line will be added to the instruction before it is obeyed (since instructions have the same form as numbers, numbers may be added to instructions to form new instructions). Suppose now that some basic set of operations is to be carried out on each of a series of numbers in the electronic store. If all the instructions required were written out in full, the instructions of one cycle would differ from those of another only in their address parts. Hence, if we let those instructions be modified by a *B*-line, and arrange to add an appropriate number into the *B*-line every cycle, it is only necessary to write out a single cycle in full.

Numerical Solution of Differential Equations

The Euler Method.—Consider the simple differential equation,

$$dy/dx=f(x, y) \quad . \ . \ . \ . \quad (A)$$

given that at $x=a$, $y=b$. Suppose we wish to find the value of y for $x>a$. The Euler method consists of putting $x=a$, $y=b$ in equation (A), thus calculating dy/dx, and assuming that this value is retained over the small interval from $x=a$ to $x=a+h$. Thus, at $x=a+h$, $y=b+(dy/dx)_a\,h=y_1$ say. At $x=a+h$, we recalculate dy/dx by putting $x=a+h$, $y=y_1$ in (A), then finding y at $x=a+2h$, and so on.

The Runge-Kutta Process.—The interval h in the Euler method has to be very small for accurate work, and it is better to use other methods which, though more complicated at each step, give greater accuracy for less computation. There are many methods of the Runge-Kutta type, and one of the simple ones is explained very briefly below. Fuller descriptions will be found elsewhere.[2]

As above, suppose we are given an equation of the form (A), with the conditions $y=b$ at $x=a$. The problem is to find the value of y when $x=a+h$, h being a not too large increment in x. The scheme of working is as follows :—

Calculate successively :

$$k'=hf(a, b)$$
$$k''=hf(a+h, b+k')$$
$$k'''=hf(a+h, b+k'')$$
$$k_1=hf(a+\tfrac{1}{2}h, b+\tfrac{1}{2}k')$$
$$k_2=\tfrac{1}{2}(k'+k''').$$

Then the final increment in y is given by

$$k=k_1+\tfrac{1}{3}(k_2-k_1).$$

If the various k's are expanded in ascending powers of h, it would be seen that the final increment in y, namely, k, agrees with the Taylor expansion of $y\,(a+h)-y\,(a)$ near $x=a$ up to and including the term in h^3.

The chief drawback of this method and other methods of this kind (from a human computer's viewpoint) is the necessity of having to make four substitutions in the expression $f(x, y)$. A human computer would generally prefer a method such as that of Adam[3] which enables him to make use of his knowledge of previously calculated intervals in order to reduce the labour somewhat. Methods of the Runge-Kutta type have a certain advantage from a machine user's point of view, in that no special starting process is required. With methods using back-information, one generally has to resort to a special starting formula in order to get the process going.

Conversion of a Given Differential Equation to a Set of First Order Equations.—This is best explained by means of an example. Consider the equation $d^2y/dx^2+\omega^2y=0$. Writing $y=y_1$, $dy/dx=y_2$ the given equation becomes $dy_2/dx+\omega^2y_1=0$. Thus we have replaced one second order equation by two first order equations :

$$\frac{dy_1}{dx}=y_2$$
$$\frac{dy_2}{dx}=-\omega^2y_1.$$

Similarly most given sets of differential equations can, by the introduction of suitable variables, be reduced to the form:

$$\frac{dy_1}{dx}=f_1(xy_1y_2\ldots\ y_n)$$
$$\vdots$$
$$\frac{dy_n}{dx}=f_n(xy_1y_2\ldots\ y_n) \quad . \ . \quad (B)$$

The Differential Equation Routine.—A sequence of instructions to solve sets of

equations of the form of equation (*B*) has been worked out once and for all, and is permanently available in the magnetic memory of the machine. This routine will be referred to as the D.E. (Differential Equation) routine.

The scheme actually adopted on the machine was developed originally for use on the Cambridge electronic computer, "EDSAC."[3] This D.E. routine carries out one step of the integration each time it is called in. That is, given all the y's at a point x, it will compute all the y's at the point $x+h$. It must be provided with an "auxiliary" routine (appropriate to each particular problem) which computes the above functions $f_1 \ldots\ldots f_n$ starting from the appropriate values of x, y_1, $y_2 \ldots y_n$. The auxiliary routine is called in four times per step.

With this process 4th order accuracy is obtained, i.e. the expansion of any $y(x+h)$ about the point x is correct up to and including the term in h^4. There is another refinement in the method of preventing the rapid accumulation of rounding-off errors.[2]

To make use of the D.E. routine to solve an equation over a finite range, say, from x_1 to x_2, a short programme has to be drawn up which first sets the initial values of the variables (i.e. their values at $x=x_1$) and then calls in the D.E. routine repeatedly until x has reached the end of the range, i.e. x_2.

Application

The following problem, which may be regarded as a typical industrial research problem, was proposed by the Shirley Institute of the Cotton Industry Research Association.

In both ring and cap-spinning air drag is a limiting factor for fine yarns. Moreover, if higher rotational speeds and larger packages are envisaged the air drag becomes important in the spinning of coarser yarns also. To determine the properties of the ballooning portions of the yarn mathematical and experimental investigation has been undertaken at the Shirley Institute.

The numerical solution of the differential equations of the ballooning curve has formed an important part in this investigation.[4]

Statement of the Problem.—The ballooning curve can be represented to a very close degree of approximation by a light, flexible thread fixed at one end and performing a steady whirling motion about a vertical axis with uniform angular velocity. Gravity may be neglected, but air resistance is taken into account by assuming that air drag is proportional to the square of the normal air velocity and that it opposes the direction of this normal component. The problem is to investigate the shape assumed by the thread under all conditions likely to arise in practice. Conditions at the other end of the thread are of no interest.

Such little experimental evidence as exists and specimen hand calculations indicate that not too far away from the fixed end the curve settles down into either something like a very flat helix or else a series of bulges. In the latter case the suggested range of integration was such as to include the first and second bulges only, i.e. the distance of a thread element from the axis to reach its second minimum. Apart from this, nothing definite can be said about how far the integration should be taken, and each case has to be judged on its own merits.

Rectangular cartesian co-ordinates X, Y, Z, are taken such that OZ (measured downwards) coincides with the axis of rotation, and OX, OY revolve with the thread in such a manner that the tangent at the fixed end of the thread at O lies in the plane OXZ. If arc length S is measured along the thread from O, the equations which determine the shape of the thread, after elimination of the tension and rearranging in non-dimensional form are :—

$$\frac{d}{dS}\left[\left(1-\frac{X^2+Y^2}{2}\right)\frac{dX}{dS}\right]+X + \lambda\sqrt{X^2+Y^2-\left(\frac{XdY}{dS}-\frac{YdX}{dS}\right)^2} \times\left[Y+\frac{dX}{dS}\left(\frac{XdY}{dS}-\frac{YdX}{dS}\right)\right]=0.$$

$$\frac{d}{dS}\left[\left(1-\frac{X^2+Y^2}{2}\right)\frac{dY}{dS}\right]+Y + \lambda\sqrt{X^2+Y^2-\left(\frac{XdY}{dS}-\frac{YdX}{dS}\right)^2} \times\left[-X+\frac{dY}{dS}\left(\frac{XdY}{dS}-\frac{YdX}{dS}\right)\right]=0.$$

$$\left(\frac{dX}{dS}\right)^2+\left(\frac{dY}{dS}\right)^2+\left(\frac{dZ}{dS}\right)^2=1,$$

where

(1) $\lambda=\dfrac{K}{M\omega}\sqrt{\dfrac{T_0}{M}}$.

(2) K is the constant in the relation : Air drag$=K$ (normal air velocity)^2 per unit length.

(3) T_0=tension at O.

(4) ω=angular velocity of spin about OZ.

(5) M=mass of thread per unit length.

The non-dimensional symbols X, Y, Z, S, used here are proportional to the actual co-ordinates and arc length. The ratio involved is $\dfrac{1}{\omega}\sqrt{\dfrac{T_0}{M}}$, which has the dimensions of length. The introduction of further variables $U=\dfrac{dX}{dS}$ and $V=\dfrac{dY}{dS}$ transforms the two second-order equations into a set of four first-order equations, in which form they may be solved directly using the differential equation routine described above :—

$$\frac{dX}{dS}=U$$

$$\frac{dY}{dS}=V$$

$$\frac{dU}{dS}=\frac{X-U(XU+YV)}{\frac{1}{2}(X^2+Y^2)-1} + \frac{\lambda\sqrt{X^2+Y^2-(XV-YU)^2}[Y+U(XV-YU)]}{\frac{1}{2}(X^2+Y^2)-1}$$

$$\frac{dV}{dS}=\frac{Y-V(XU+YV)}{\frac{1}{2}(X^2+Y^2)-1} + \frac{\lambda\sqrt{X^2+Y^2-(XV-YU)^2}[-X+V(XV-YU)]}{\frac{1}{2}(X^2+Y^2)-1}$$

. . . . . (*C*)

Initial Values and Solution Parameters.—At the origin where $S=0$ we have $X=Y=Z=0$. Moreover, the axes were chosen so that here $V_0=dY/dS=0$. This leaves the value of $U_0=dX/dS$ at $S=0$ still at our disposal. Thus, there are essentially only two solution parameters λ, depending on the air drag coefficient and other physical quantities, and U_0, defined above.

The Z Co-ordinate.—The equation

$$(dX)^2/(dS)^2+(dY)^2/(dS)^2+(dZ)^2/(dS)^2=1$$

could have been treated as a fifth differential equation to be added (after slight rewriting) to the above set of four. However, Z is not required in the solution of the equations for X and Y, so that time can be saved by finding Z as the integral $Z=\int\sqrt{1-U^2-V^2}dS$. The increment to this integral is found after every application of the main differential equation routine. The sequence of instructions used for this purpose is based on the third order approximation obtained by passing a parabola through the point on the curve $\sqrt{1-U^2-V^2}$ last computed, and the two preceding points.

Printing Requirements.—It was arranged to have four columns of printing, corresponding to X, Y, $\sqrt{X^2+Y^2}$, Z. Since these results are ultimately to be plotted graphically five significant digits were considered ample in each case.

The Routines Required.—The programme consists of a "master routine" linking together various sub-routines. Thus we have

(1) A routine for the solution of a system of simultaneous differential equations, as described above.

(2) A "Conprint" routine which takes care of the binary-decimal conversion and prints out a number represented in a particular storage location.

(3) and (4) Two routines for evaluating reciprocals and square roots.

These four routines are of perfectly general nature, and can be used without modification in any other problem where they may be required.

The following three routines represent programming done specifically for this problem :—

(5) An "auxiliary" routine, as described above to evaluate quantities k_1 to k_4, which are proportional to the right-hand sides in equations (*C*). This routine makes use of routines (3), (4), above.

(6) A "layout" routine, which organises one line of printing, namely, X, Y, $\sqrt{X^2+Y^2}$, Z. This routine makes use of (2) and (4) above.

(7) Finally, the "master" routine, which links all the above together, and performs also miscellaneous duties such as calculating the Z increment from the integral for Z.

The above routines require a total of six tracks only, an almost insignificant number compared with the total magnetic memory of 256 tracks. Most industrial problems would certainly make use of a greater proportion of the magnetic memory, especially where there is a large amount of numerical data to handle.

General Considerations

Clearly any solution we get out of the machine will depend on :

(1) The value of h (the basic interval),

(2) The two parameters λ, U_0.

The choice of a value for h (used in the auxiliary routine) is a matter of some importance. At every step two different kinds of errors are introduced. First, there are truncation errors, which arise through, in effect, "truncating" the series expansion of the solution at some definite power of h. Secondly, since we have to work with numbers of finite length there will be rounding-off errors at every step. Too small a value of h will increase the number of steps required, thereby increasing the total round-off error as well as the solution time. On the other hand, too large an interval, while reducing the solution time, may introduce intolerable truncation errors. The best approach in this case is the empirical one, i.e. two solutions are produced for the same pair of parameters λ, U_0, but for different h's. Comparison of the solutions then gives information from which a reasonable h can be chosen.

The two solution parameters λ, U_0 have to be fed into appropriate lines of the c.r.t. store on tape by means of the input routine described above prior to every run. An alternative to this would have been to arrange a little routine to generate the pairs of values required. The former, more flexible, method was preferred, chiefly because

of the fact that it was impossible to say until immediately before the solution was begun just what pairs of values would be required.

In problems of this nature it would be quite unnecessary to print out all the results computed by the machine. It was considered sufficient to print out results every five or ten steps. After a few trial runs it was decided to take an $h=0\cdot02$ and to print out the relevant results every ten steps. Thus printed results appeared at intervals of $0\cdot2$. secs.

The Master Routine

This is best explained by reference to the flow diagram given in Fig. 1. This consists essentially of three loops and an "initial" part. These loops can be likened to a train of three wheels in some mechanical counting device, where say five turns of the first cause one turn of the second, and ten turns of the

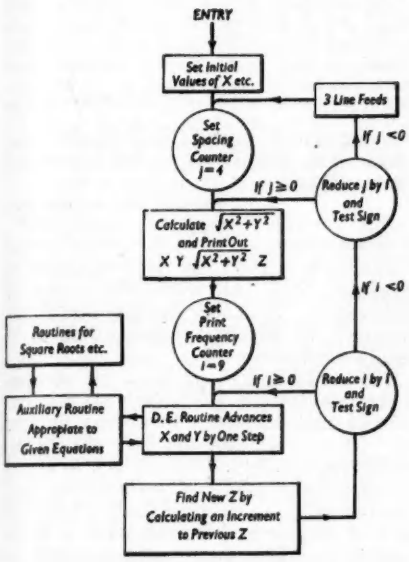

ENTRY
Set Initial Values of X etc.
3 Line Feeds
Set Spacing Counter j=4
If j<0
If j≥0
Reduce j by 1 and Test Sign
Calculate √(X²+Y²) and Print Out X Y √(X²+Y²) Z
If i<0
Set Print Frequency Counter i=9
Routines for Square Roots etc.
If i≥0
Reduce i by 1 and Test Sign
Auxiliary Routine Appropiate to Given Equations
D.E. Routine Advances X and Y by One Step
Find New Z by Calculating an Increment to Previous Z

Fig. 1—Block Diagram of Computer

second cause one turn of the third. The method of counting is typical of techniques employed in electronic computing. Thus, to count n operations we employ a counter j which starts at $n-1$, and counts down to zero, stopping when it reaches -1. The scheme is best set out as follows :—

Set counter j to $n-1$
OPERATION
Reduce j by 1
Test sign of j
If $j<0$ STOP
If $j>0$ return to operation

The "operation" involved may be anything we please, such as carrying out one step of the integration or printing one number, &c. Testing the sign of j could be done in the accumulator (as described under the heading $D(2)$—conditional transfer of control). A more convenient method, however, is to store the counter j in one of the eight subsidiary accumulators called B-lines, since instructions of the group $D(2)$ exist for B-lines also.

The innermost loop consists essentially of the D.E. routine itself and the short sequence of instructions for finding the Z-increment as explained on page 38. Suppose we wish to print out results every ten steps, i.e. at intervals of $0\cdot2$ in arc length S. Then setting the print-frequency counter i to 9 initially and counting as explained above will ensure that this loop is described ten times, i.e. the integration is carried forward by ten steps. When the counter i has reached -1, we leave this loop and print out results at the last point calculated. In a like manner, the second loop is described five times by setting the spacing counter initially to 4. The purpose of this is to break up the printed results into blocks of five lines for ease of reading. After these five lines of printing the machine will give three extra "line-feeds" on the printer, after which the spacing counter is reset to 4 and the whole process starts again. In view of the lack of good criteria for determining the end of a run, the machine was simply stopped by hand when it was considered that the integration had been taken far enough.

Generally speaking, however, in most problems one can usually arrange some test which stops the machine at the end of a calculation.

The "initial" part of the master routine performs miscellaneous duties such as setting the initial values of the variables X, Y, U, V, and also the parameters used in printing. For example, the "Conprint" routine, being one of very general nature, must be given information about the scaling (page 38) of the numbers it is going to print out, and also the number of decimal digits required.

Machine Operation and Checking

Before the machine can be made to do a calculation, it is first necessary to ensure that all the routines required are stored on the magnetic drum. Library routines (i.e. those of quite general nature) may be supposed to be there already, while routines written specifically for some problem are first punched on paper tape, read into the c.r.t. store by means of the input routine, and then sent to the magnetic tracks. The machine must also have information about the track numbers on which the various routines are written.

If we assume that the machine has been thus prepared for the present problem, the next step is to feed a pair of solution parameters λ, U_0 on tape into the allotted lines in the electronic store. The same short length of tape may also contain an instruction to bring down the master routine from the tracks, and let the machine start computing.

After this, no manual intervention is required until inspection of the printed results shows that the limit of useful integration has been reached. (Rough criteria for this are given on page 38.) Here, the machine is simply stopped by hand. This point generally occurred between $S=4$ and $S=7$. The following figures may be of interest. They represent no particular case exactly, but are fairly typical.

Range of independent variable	$S=0$ to $S=6$
Total computing time	27·5 minutes
Total printing time	2·5 minutes
Number of intervals ($h=0\cdot02$)	300
Computing time for single interval	5·5 seconds
Printing time for single row of results	5 seconds

The total time per run, namely, thirty minutes, may be compared with the time required by a single operator to do the same problem with a desk machine, i.e. 160 hours or more. Since the uniform pattern of behaviour of the computer is to calculate ten intervals and then print, the machine gives the impression of working in 60 second cycles, each cycle being composed of 55 seconds "thinking" and 5 seconds printing. A point of interest is that the total time per run is largely determined by the time spent in the innermost loop (5·5 seconds each time round). This is because the printing time is less than 10 per cent of the total. In other problems there may be a different balance. If, for example, the machine were used with its present teleprinter output for pay-roll calculations, computation time would be trivial compared with printing time.

There remains the question of ensuring that the machine has not produced an incorrect result. There are various ways of doing this, each providing a certain degree of cover against transitory machine errors. Permanent machine faults are not dangerous in this sense, since the answers produced by a machine with a permanent fault are in general obviously incorrect. Again, the checking technique may be based on some numerical property (e.g. a square root may be checked by forming its square), or, on the other hand, every calculation may be simply repeated. The exact checking procedure depends to a large extent on the kind of problem and in the present instance it was decided to check by repetition with a different interval. It was not considered necessary to repeat every run, and the compromise was made of checking every fifth

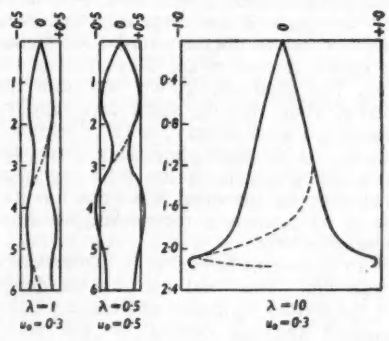


Fig. 2—Specimen Results

solution. The check solutions were done with an interval $h=1/60$, and the programme modified slightly to print every twelve steps. The purpose here is that, in addition to the check on machine consistency, there is also a check on the magnitude of the truncation errors (page 38).

Results

In all, the equations were solved for twenty-one sets of parameters. In this article we content ourselves with reproducing only three cases of the complete set of results. The three specimen results are given in graphical form in Fig. 2. The solid outer line represents the enveloping surface, i.e. the actual appearance of the rapidly spinning thread. The dotted inner line is the projection of the thread on to the (revolving) vertical plane through the axis, i.e. the plane $Y=0$.

The complete set of results is given in the companion paper (Ref.[4]), where they are also discussed from a technological viewpoint.

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[3] S. Gill, "A Process for the Step-by-Step Integration of Differential Equations in an Automatic Digital Computing Machine." *Proc. Cam. Phil. Soc.*, Vol. 47, Part I.

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Civil Helicopter Delivery.—British European Airways Corporation has taken delivery of the first of two Bristol type "171," Mk. 3A helicopters to be used for passenger services linking London with major provincial cities. The type "171" has accommodation for four passengers, and becomes the first British helicopter to be purchased by a British airline for the operation of scheduled passenger services. The aircraft is basically similar to other marks in military use, but has been specially modified for passenger services. It is claimed by the company that as this helicopter operates with a relatively high rotor speed the increased kinetic energy thus stored is sufficient to ensure safe engine-off landings

Regime Flow in a Silt Carrying Channel

By J. F. COOKE, M.A.

THE theory and formulæ of Mr. Gerald Lacey on regime flow in silt-transporting channels are widely known. They are published in *Regime Flow in Incoherent Alluvium*, Central Board of Irrigation Publication No. 20, Simla, 1939, and in Mr. Lacey's original paper, "Stable Channels in Alluvium," *Proc. Inst.C.E.*, Vol. 229, 1930. Some while ago an exceptional opportunity of checking these formulæ occurred in a small canal, with results which are of some interest.

The canal, which is a part of the Gezira scheme in the Sudan, had run for some fifteen years without ever having been cleared of silt. Originally it had been dug much too wide in order to obtain material for banks, but berms, formed of the silt carried in the water, had gradually grown out from the sides at about highest water level and so restricted the waterway to a "regime" section. At the same time, since there was ample fall available at the head regulator which supplied the canal, the slope too was able to build up to a regime and no more silt was deposited.

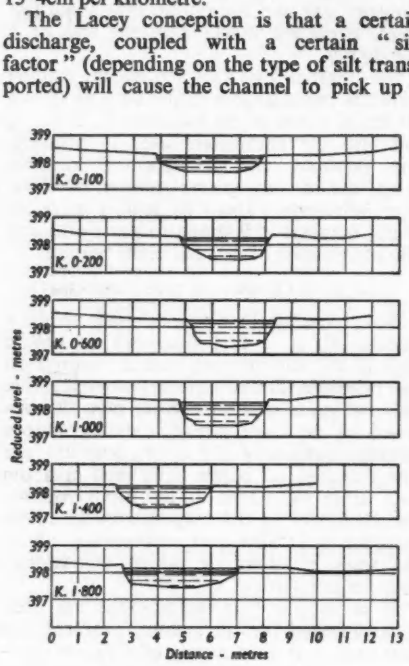
With the means to pick up a regime water section and slope, and no possible doubt that the wetted perimeter was entirely composed of the silt carried by the water itself, an unrivalled opportunity thus presented itself for a comparison with the Lacey formulæ. The canal, though short (only 2·112km in length), had no intermediate offtakes, but supplied three minor canals at its tail, where the level was always maintained constant within an inch or two. Some of the actual water sections are shown in the accompanying illustration. It is emphasised that these sections were taken with particular care, the idea of this investigation having sprung from a study of the ordinary routine cross sections taken to see if clearance was necessary.

The Lacey regime postulates a constant discharge, which presents a practical difficulty in the application of the formulæ. In the Gezira scheme the water is richest in silt in August and September, decreasing gradually to almost nil in November. Peak water demands occur in September and October and thus coincide with the last of the heavily silted water. Clearly these last big, "red water," discharges are the ones applicable to the Lacey formulæ. The discharges for the previous year are listed in order in Table I; the highest discharge was 74,000 cubic metres per day, except for twenty-four hours at 81,000 cubic metres per day, which is ignored. The picture for the previous year was much the same, and the figure of 74,000 cubic metres per day was therefore selected with some confidence. The slope, taken from Table I, was 15·4cm per kilometre.

TABLE I—*Highest Discharges*

Date	Q	W.L. d/s head regulator	W.L. K·2112	Slope
	Thou. m³/day	m	m	cm/km
Sept. 28th	81	398·39	398·05	16·4
Sept. 25th	74	8·35	8·04	14·9
Sept. 26th	74	8·36	8·04	15·4
Sept. 27th	74	8·37	8·05	15·4
Aug. 14th	70	8·26	8·01	12·0
Oct. 2nd	70	8·38	8·05	15·9
Oct. 3rd	70	8·38	8·06	15·4
Oct. 4th	70	8·39	8·08	14·9
Oct. 5th	70	8·41	8·08	15·9
Oct. 7th	70	8·41	8·08	15·9
Oct. 8th	70	8·40	8·09	14·9
Oct. 9th	70	8·40	8·10	14·4
Oct. 10th	70	8·38	8·10	13·5
Sept. 23rd	67	8·29	8·02	13·0
Sept. 24th	67	8·31	8·02	14·0
Oct. 12th	67	8·38	8·11	13·0
Oct. 13th	67	8·37	8·10	13·0
Oct. 14th	67	8·37	8·10	13·0
Oct. 15th	67	8·38	8·10	13·5

N.B.—Design W.L. at K2·112 is 398·05m R.L.



Cross Sections of Canal

The Lacey conception is that a certain discharge, coupled with a certain "silt factor" (depending on the type of silt transported) will cause the channel to pick up a certain definite water section and slope. When it has done so it will be in regime and no more silt will deposit. The water section is defined by the formulæ in terms of wetted perimeter and hydraulic mean depth.

In this case, the silt factor f is not known. It can, however, be obtained by working back from the dominant discharge and slope. Since Lacey's formulæ are in foot units a conversion to metric is necessary (i.e. 3·281ft per metre). The calculations are as follows:

Notation.

A=area in square metres.
R=hydraulic mean depth in metres.
P=wetted perimeter in metres.
Q=discharge in cubic metres per second.
S=water slope.
f=silt factor.
V=velocity in metres per second.

Data.

Q=74,000m³/day=0·8565m³/sec.
S=0·000154.

Computation.

(i) Formula $S=\frac{f^{5/3}}{1844Q^{1/6}}\times\frac{1}{3\cdot281^{1/2}}$,

and knowing S and Q,

therefore f=0·6607.

(ii) Formula $P=\frac{8}{3}Q^{1/2}\times3\cdot281^{1/2}$,

and knowing Q,

therefore P=4·471m.

(iii) Formula $R=\frac{3}{2^{2/3}}\left(\frac{Q}{f}\right)^{1/3}$,

and knowing Q and f,

therefore R=0·5152m.

From the foregoing we may obtain

(i) $A=PR$=2·303m².

(ii) $V=\frac{Q}{A}$ =0·3718m/sec.

The actual sections, some of which are shown in the illustration, were now measured; the results are shown tabulated in Table II. The mean values of area and wetted perimeter from Table II may be compared with the Lacey values computed above. Thus:

TABLE II—*Section Measurements*

C.S. at	Area, A	Wetted perimeter P	Water depth D	Surface width W	Remarks
Km	M²	M	M	M	
0·100	(2·45)	(4·70)	(0·71)	(4·1)	Ignore
0·200	2·17	4·15	0·80	3·5	—
0·400	2·28	4·15	0·84	3·4	—
0·600	2·36	4·15	0·89	3·3	—
0·800	2·30	4·35	0·76	3·8	—
1·000	2·20	4·20	0·78	3·6	—
1·200	2·19	4·10	0·77	3·5	—
1·400	2·24	4·20	0·75	3·7	—
1·600	2·24	4·50	0·70	3·9	—
1·800	(2·28)	(4·80)	(0·65)	(4·3)	Ignore
Mean	2·25	4·23	0·79	3·56	—

Note.—Water surface is taken as 398·36 d/s head and 398·04 at K2·112.

	Lacey	Actual	Difference, per cent
Area	2·30m²	2·25m²	2·2
Wetted perimeter	4·47m	4·23m	5·4

This is a remarkably high measure of agreement, and well within the errors of observation. The Lacey formulæ would thus appear to be directly applicable even to so small a canal as this.

The semi-elliptical shape of the sections is most noticeable, particularly at sections K1·000 and K1·400. It is true also at K0·100 and K1·800, but here the depth/width ratio is different, due perhaps to effects of entry and draw-off of water at the head and tail of the canal respectively. That the sections are, in fact, semi-elliptical is easily confirmed. The mean surface width is 3·56m and the mean depth 0·79m (Table II), and if a semi-ellipse is drawn with these as major and semi-minor axes respectively, it will give:

Area	2·22m²
Perimeter	4·04m

These values are sufficiently near the measured figures to confirm that the sections are approximately semi-elliptical. Naturally, due to irregularities, the measured wetted perimeter from Table II is somewhat higher than that of a perfect semi-ellipse.

The roughness in terms of Manning's "n" may be obtained from the Manning formula $Q=A\frac{1}{n}R^{\frac{2}{3}}\sqrt{RS}$. The computed Lacey figures are sufficiently close to the measured values of A and R to make no difference, and in either case,

n=0·0214,

which is about the value to be expected.

Although this is a small and rather short canal, it had a unique opportunity to pick up a silt-carrying regime in a bed of its own making. Comparison of the regime cross section with that of the Lacey formulæ shows an astonishingly close agreement, and the semi-elliptical shape of the cross sections is of interest.

KWINANA REFINERY.—At the Kwinana refinery which is being built for the Anglo-Iranian Oil Company, Ltd., in Western Australia, site work has made considerable advances and the concrete foundations for the two distillation units and other structures are being poured, while two self-propelled dredgers have removed 1,500,000 cubic yards of sand from the sand banks at the entrance to Cockburn Sound.

The Royal Show at Blackpool

No. II—(*Continued from* **page 11,** *July 3rd* **)**

THE Royal Agricultural Society's annual show opened at Stanley Park, Blackpool, on Tuesday last, July 7th, under the presidency of the Earl of Derby. It will close this evening, July 10th. As usual, the show is attracting a large number of visitors from all parts of this country and also from many countries overseas. Fortunately, this year there has been no serious outbreak of foot and mouth disease to affect the livestock exhibits.

With the continual progress in this country of a mechanised agriculture, the machinery stands are again drawing many visitors. The displays on those stands indicate clearly that engineers are making a worthy contribution to the success of this country's agriculture and, indeed, to the agriculture of the world, for many of the implements and machines exhibited have been designed specially for use in undeveloped overseas territories. In addition to the trade stands there are several items of technical and educational interest which are provided by various associations and by the Ministry of Agriculture. One such exhibit, which has been staged by the Rural Industries Bureau, shows the variety of the rural crafts that are still followed in this country. Other exhibits demonstrate the use of electricity in agriculture and horticulture, and the most economic use of solid fuel.

Following its usual procedure, the Royal Agricultural Society is making awards of silver medals in respect of new implements, on which full test reports have been made available. Ten entries of new implements and devices were accepted this year for adjudication, together with five others which were deferred from last year's Royal Show. The judges for the new implements are Mr. A. Herbert Carter, Major T. K. Jeans and Mr. Leslie Langmead. At the time of going to press with this issue, their awards have not been made known.

We continue below our descriptions of some of the machines and implements which are exhibited at the show.

Rotary Hoes, Ltd.

In an article on the machinery at the Smithfield Show, which appeared in THE ENGINEER of December 12, 1952, we described and illustrated the "Platypus" crawler tractor and the 6ft trailing "Rotavator," which had just been put into production by Rotary Hoes, Ltd., Horndon, Essex. These machines, together with other products of Rotary Hoes, Ltd., are exhibited at Blackpool on the stand of J. S. Ramsbottom (Kirkham), Ltd.

In Fig. 6 we illustrate the Howard trench-digger which has been specially designed for and fitted to the "New Fordson Major" diesel tractor. This trench digger is a complete modernisation of the "Roteho" digger produced in limited numbers during the last war by Rotary Hoes, Ltd. There is also included with it a pipe layer—not shown in our illustration—so that the cutting of trenches and the laying of drainage tiles can be performed in one operation. The trench digger is mounted at the rear of the tractor and can be raised and lowered either by a hydraulic ram, which is operated by the tractor pump, or by winch and cable. The winch and cable are also used to hold the machine in the elevated position for transport. Power for operating the digger is taken from the power take-off shaft of the tractor through a bevel gear to a heavy roller chain drive, and thence through spur reduction gearing to the rotor, the spindle of which is carried on heavy ball bearings. On the rotor, the overall diameter of which is 6ft., there are mounted twelve spade-shaped blades which can dig to a maximum width of 9in and a maximum depth of 3ft 6in. The crumb which is left by the blades is collected by a scoop-shaped scraper blade which can be adjusted to suit varying depths of trench. As the digging blades lift the spoil it is deposited beside the trench and there formed into a ridge by a mould board, the sole plate of which also acts as a depth control. Top and bottom scrapers are fitted to clear the soil from the rotor blades, and there is also a scraper to keep the rotor face clean. A grading system is provided by the use of sighting bars and jackshafts are supplied for setting at various levels to produce correct grading at the bottom of a trench.

The pipe layer is attached to the scraper blade of the trench digger. It consists of a chute, down which the pipes slide, mounted on a base. The forward end of the base sweeps aside any small deposit of crumb remaining in the trench and check plates prevent any crumb from falling into the trench until the pipes are laid. The keel-shaped bottom produces a concave groove in the trench in which the pipes are deposited. To the rear of the base there is attached a cast iron roller which runs over the pipes to ensure their even bedding and correct alignment.

As will be noted from the illustration, the tractor to which the trench digger is fitted is equipped with "Rotapeds" to reduce ground pressure and to improve traction. It is also fitted with cast iron front wheels in order to improve the balance and to faciliate steering. For operating the digger, an additional gearbox, giving a reduction of 22 to 1, has been built into the tractor gearbox. The overall length of the complete outfit is 18ft and its width 6ft 5in.

The Nuffield Organisation

Eight of the tractors which are to be displayed by the Nuffield Organisation, Cowley, Oxford, are equipped with a new vapourising oil engine introduced recently by Morris Motors, Ltd. It is a four-cylinder engine, developing 35 b.h.p. at 1400 r.p.m. and 43 b.h.p. at 2000 r.p.m., the compression ratio being 4·25 to 1. Coil ignition is employed in conjunction with a 12V battery. A Nuffield tractor fitted with this engine is shown in Fig. 7. In addition to the new engine, there has been a modification of the hydraulic power unit for the Nuffield tractor. When using certain implements which are operated by the hydraulic lift and the power take-off, it is an advantage to be able to disengage the power take-off and still retain the use of the hydraulic lift. The modification of the hydraulic lift on the Nuffield tractor enables the order of power selection to be (1) neutral (hydraulic lift and p.t.o. disengaged); (2) hydraulic lift engaged; (3) hydraulic lift and p.t.o. shaft engaged. The method of selection is made possible by mounting the hydraulic pump driving gear on a hollow shaft through which the p.t.o. shaft operates. Operation of a hand selector lever actuates a selector fork which slides the hollow shaft into splined engagement with the constant speed layshaft, and thus brings the hydraulic lift into gear. A further movement of this lever brings a second set of splines in the hollow shaft into engagement with the splined end of the p.t.o. shaft, so that the hydraulic lift and the p.t.o. shaft are engaged simultaneously.

Another recent addition to the Nuffield tractor is an overload release mechanism which stops the tractor should an implement attached or mounted to it encounter an obstruction. This device operates in conjunction with the drawbar and the hand clutch. It consists of a spring-loaded anchorage for the drawbar frame which is adjusted to withstand the normal resistance of the implement at work. Any increase in this load, caused by obstructions such as tree stumps, tough roots or large stones, trips the clutch. The tripping mechanism can be adjusted by a handscrew situated conveniently near to the tractor driver.

Harry Ferguson, Ltd.

Four of the new implements which are exhibited by Harry Ferguson, Ltd., Coventry, have been designed to meet the requirements of various territories overseas. These implements are a "polydisc" seeder and cultivator, a mounted reversible heavy-duty disc harrow, a disc terracer, and a corn and cotton planter.

The corn and cotton planter is illustrated in Fig. 8. It is a mounted implement which has been designed for the precision planting of a variety of seeds of which maize and cotton are

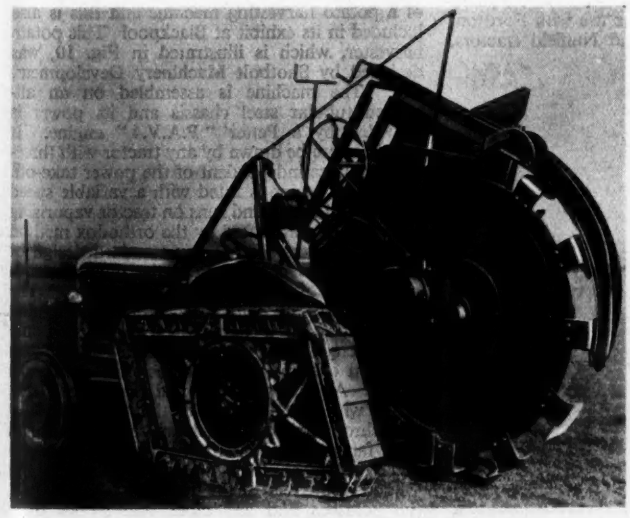


Fig. 6—Trench Digger—Rotary Hoes

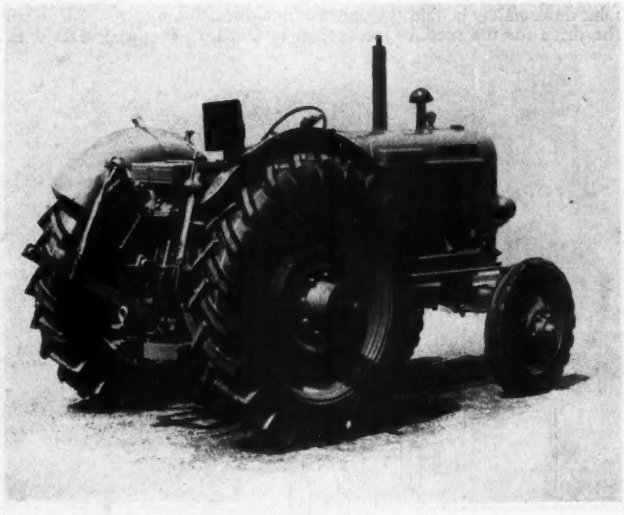


Fig. 7—"M4" Tractor—Nuffield

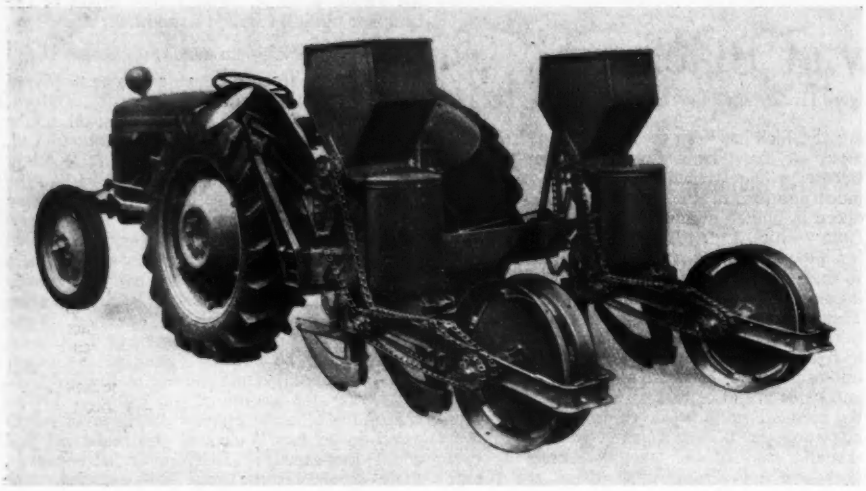


Fig. 8—Corn and Cotton Planter—Ferguson

the most important. Our illustration shows the two-row version of the planter. Each planting unit consists of an open centre press wheel, seed hopper and seeding mechanism, chain drive and furrow opener. The fertiliser hopper with its distributing mechanism, which is also chain driven, is mounted above and just in front of the seed hopper. The planting and fertiliser units are connected through a parallel linkage to sliding mounting brackets attached to a rigid box section frame, the parallel links enabling each unit to ride independently over the ground. At either end of the main frame there is a telescopic disc marker which can be lowered by a hand lever easily accessible to the tractor driver, and is raised automatically whenever the planter itself is raised on the tractor linkage. The cotton planting mechanism is a picker wheel, and for corn seeding variations in spacing from 1½in to 28in can be made by changing the sprockets on the press wheel and hopper drive shaft. The capacity of each seed hopper is rather more than half a bushel.

In Fig. 9 there is reproduced a photograph of the polydisc seeder and cultivator which has been produced primarily for tropical and subtropical countries. The implement is mounted on the tractor by attachment to the three-point linkage, and its framework, which is of all-steel welded construction, incorporates a weight box and a retractable parking stand. The seed hopper, which has a capacity of four bushels, is made of zinc plated mild steel. There are seven seeding units, the seeding mechanism being of the external forced feed fluted roller design and to deal with different sizes of seed adjustable feed gates have been fitted. The seed falls from the hopper through wire reinforced, rubberised canvas flexible tubes to a point immediately behind the centre of the discs. The drive for the seeding mechanism is taken, as shown in the illustration, from a spring-loaded detachable landwheel through chain and sprockets and a telescopic shaft with universal joints to the gear unit beneath the hopper. The seeding rate is thus always directly proportional to the forward speed of the tractor. The cultivating discs—which can be 22in or 24in diameter—are of carbon steel, and a spring loaded furrow wheel, the angle of which can be adjusted between 0 deg. and 15 deg., has been fitted to prevent side draught and control the front furrow width.

There are many other implements shown by the firm in company with a selection of its tractors. One recent addition to the Ferguson equipment is a telescopic jib crane which is mounted on the rear of a tractor. It is supported on a tubular steel frame, the whole assembly being attached to the tractor's three-point linkage. The length of the jib is adjustable through seven positions, ranging in 5in steps between 4ft 2in and 6ft 11in. The maximum lift height of 7ft 4in under the hook is obtained when the jib is raised in the fully extended position, the maximum lift height being 5ft when the jib is raised and fully retracted. With the jib fully extended, a weight of approximately 3 cwt can be handled.

Bamfords, Ltd.

Among the exhibitors of long standing at the Royal Show is the firm of Bamfords, Ltd., Uttoxeter, Staffs. The firm's display this year includes a selection of the grass mowers and hay-making machinery which it manufactures, oil engines for a variety of agricultural purposes, and other items of equipment, such as manure distributors, root cutters and grinding mills. One of the firm's latest products is a mid-mounted mower, which is suitable for use with Fordson, Ferguson, David Brown and Nuffield tractors.

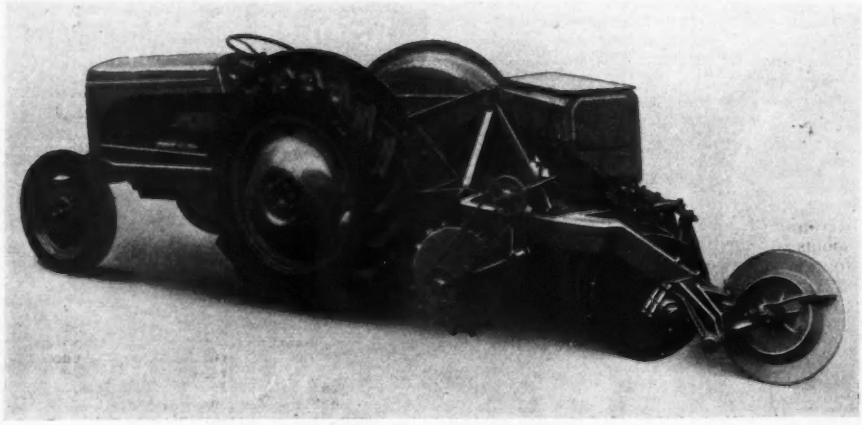


Fig. 9—Polydisc Seeder and Cultivator—Ferguson

The mower is carried on fixed brackets which can be permanently secured to the tractor, and there is a safety "break back" of the cutter bar, through a wide angle, which gives adequate protection to the machine if an obstruction should be encountered. The mounting between the tractor and the mower is through a rubber bush so that the vibration of the mower during operation is damped out and not transmitted to the tractor. The main drive to the mower is transmitted from the tractor's power take-off shaft by a dual "V"-belt.

Another new production which is shown by Bamfords, Ltd., is a saw bench suitable for general and agricultural use. The table, which is 4ft 2in long and 2ft wide and the height of which is 2ft 6in from the ground, is of planed cast iron and is fitted with a loose centre piece to permit the easy removal of the saw. A 30in standard diameter saw is carried on a solid steel spindle which runs in self-aligning ball bearings and the 7in by 3½in pulleys are equipped with a belt shifter. The bench is provided with a fence which can be adjusted horizontally or to any angle for bevel cutting and there are also top and bottom saw guards. The power required is from 3 b.h.p., dependent, of course, upon the size of the saw and the nature of the work, and the speed range is from 900 to 1200 r.p.m.

Some new models have lately been added to the firm's "Z" series of direct-injection diesel engines and examples of them are to be seen at the show. They include the "Z7" twin-cylinder 14 b.h.p. engine in which pressure lubrication has been introduced for the main bearings and valve gear, the big ends being lubricated by dipper.

Catchpole Engineering Company, Ltd.

The mechanical harvesting of root crops is a matter which continues to engage the attention of several agricultural engineering firms. In particular, in recent years considerable progress has been made with machines for the complete harvesting of the sugar beet crop. The Catchpole Engineering Company, Ltd., Bury St. Edmunds, Suffolk, is one of the firms which is exhibiting beet harvesting machinery. In addition to a machine which combines a topping unit, a digger and a delivery elevator, there are shown on the firm's stand a beet-top harvesting machine and a tractor-mounted pick-up loader which can also deal with bales or sacks. As well as beet harvesting equipment, the Catchpole Engineering Company, Ltd., is exhibiting its "Taxigraine" precision drill, which has been devised specially for the accurately spaced planting of sugar beet seed. Earlier this year the drill took part in the competition organised by the Ministry of Agriculture's sugar beet research and education committee and the makers were awarded a second prize in the class for production models of spacing drills. A brief description of the "Taxigraine" was printed in The Engineer of April 24th last.

Within the last year the Catchpole Engineering Company, Ltd., has taken up the production of a potato harvesting machine and this is also included in its exhibit at Blackpool This potato harvester, which is illustrated in Fig. 10, was designed by Shotbolt Machinery Development, Ltd. The machine is assembled on an all-welded tubular steel chassis and its power is provided by a Petter "P.A.V.4" engine. It can therefore be drawn by any tractor with three-point linkage independent of the power take-off. The Petter engine is fitted with a variable speed control and clutch and runs on tractor vaporising oil. Potatoes are lifted by the orthodox method of chain diggers so that any standard design of digging shares can be used, the digging depth being controlled by screw adjustment. The potatoes, together with clods, stones and haulm, pass on to rod-link chains which are agitated only for the length of the normal chain digger, and they are then elevated to an extension of the same chain. As the potatoes and the clods, &c., raised with them move over this extension they pass through an air stream which is maintained by a fan mounted on the front of the machine and by this means the haulm is blown out through a hood at the rear of the harvester. Meanwhile, the potatoes and any clods and stones drop into the shallow section of an "L"-shaped tank containing a suspension of earth in water

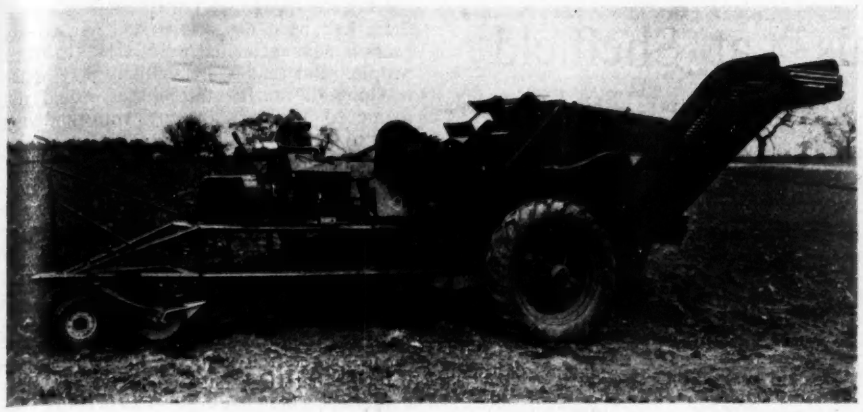


Fig. 10—Shotbolt Potato Harvester—Catchpole

having a specific gravity above that of a potato. Consequently, the potatoes float and the clods and stones go to the bottom. The potatoes, clods and stones are then swept along by rubber fingers across into the deeper part of the tank; the floating potatoes being passed on to an elevator which transports them into a trailer drawn alongside. As the potatoes are taken up the final elevator, the bottom of which is in the separating tank, they are sprayed with clean water which is carried in an 80-gallon water supply tank on the machine—the water is pumped to the spray nozzle at a pressure of 40 lb per square inch.

The spray fulfils two purposes. It cleans off the dirty water from the potatoes and maintains the correct density of the suspension in the separating tank. The clods and stones having sunk to the bottom of the deep part of the tank are removed by a rod-link elevator, running parallel with the potato rows, and are deposited on the ground. The pneumatic-tyred landwheels of the harvester are adjustable mechanism is driven from an eccentric pulley on the feed elevator shaft and the height of cut can be adjusted between 2in and 20in by a lever operated by the tractor driver. The cut crop is taken by a shallow-angle canvas conveyor, at the top of which there is a three-bladed rotor to assist even feeding into the threshing drum. This drum is 17in in diameter and 42in wide and is fitted with six steel beaters. A lever on the side of the combine regulates the movement of the concave towards or away from the drum, as may be required by the condition of the crop, and the threshed grain is delivered to the sieves through a return pan. Meanwhile the straw passes over a shaker rack, which is 75in long, and any grain which is shaken out falls on to the return pan underneath. Two moving sieves are incorporated in the harvester, one for chaffing and one for cleaning. A four-bladed fan provides the air blast which passes to each sieve through ducts equipped with adjustable valves. Two augers then collect the grain and the tailings and deliver them to their respective

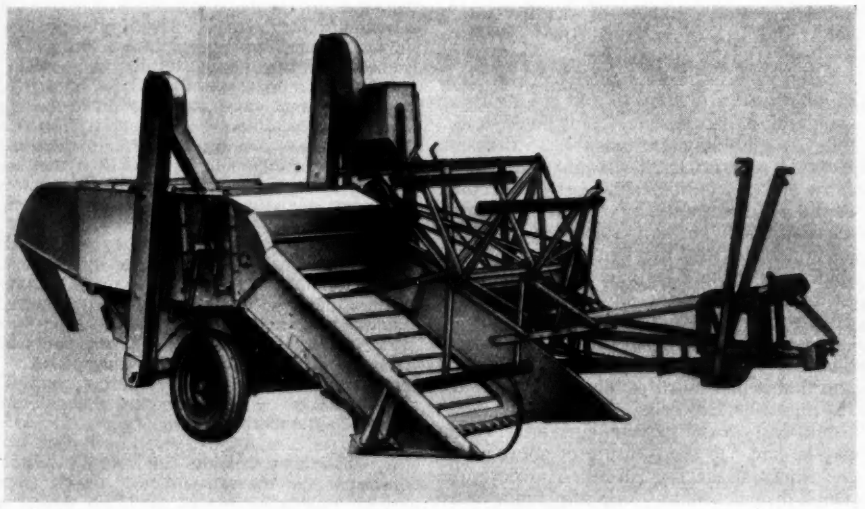


Fig. 11—4ft Combine Havester—Ransomes

for row widths and safety slip clutches are provided at four points throughout the machine. The clutches are of ratchet pattern and give audible warning when slipping.

RANSOMES, SIMS AND JEFFERIES, LTD.

This year Ransomes, Sims and Jefferies, Ltd., Orwell Works, Ipswich, are exhibiting a 4ft combine-harvester, of Swedish design, which it is now manufacturing. A photograph of the machine is reproduced in Fig. 11. The overall width of the combine when in work is 12ft 6in and power for its operation can be taken from a tractor of 25 h.p. and upwards. The knife elevators. From the grain auger the clean grain is carried to the hopper by a rubber paddle elevator. The grain hopper has two bagging spouts and below it a roomy platform is provided for the operator. Power for the operation of the combine is taken by universal jointing from the tractor power take-off, through a gearbox and pulleys to the drum shaft. All the shafts, with the exception of the reel, are fitted with ball bearings. The machine is assembled on a main frame, made of channel steel, which is carried on two pneumatic-tyred wheels running on conical bearings.

(*To be continued*)

Radio Telephone Network for Nigeria

IN order to improve and extend their communications system the Posts and Telegraphs Department of Nigeria has ordered equipment for a large network of very high-frequency multi-channel wireless stations. This network will link the telephone systems of many towns and will provide more channels on existing overhead wire routes. The order has been placed, through Crown Agents for the Colonies, with Marconi's Wireless Telegraph Company, Ltd., who have already installed part of the scheme and carried out extensive survey work. It will be possible, when the scheme is completed, to telephone from Lagos to many places which have never had telephone communication with the coast before.

The beginning of the network, the link between Lagos and Ibadan, has already been installed and the rest of the links will join the provincial capitals of Kaduna and Enugu, to Ibadan through the towns of Ilorin, Minna, Lokoja, Onitsha and Benin City.

At various points along these routes radio repeater stations are being set up and arrangements will be made for channels to be dropped out to enable small local telephone exchanges to be connected into the main scheme. The network provides twin-path v.h.f. multi-channel interconnections. One path will carry eight trunk or through telephone channels, whilst the other carries four telephone channels, one of which will carry six telegraph circuits for local working.

Due to the undeveloped nature of the territory, particular consideration has had to be given at each station to power supplies and at most of the stations duplicate diesel alternators (which have been specially designed and manufactured for this type of service) will be installed.

Progress of a Diesel Engine Works

THIS year marked the coming of age of F. Perkins, Ltd., and in celebration of the event the company held a "Works at Home" on July 1st, when the members of the technical press were able to visit the works at Peterborough. The guests were welcomed at luncheon by Mr. F. A. Perkins, the chairman and managing director of the company, who recalled that when the company was founded in 1932 the objective was to establish the Perkins engine as a standard power unit for road transport, agricultural purposes and high-speed motor boats. As a measure of the success of the engine, as developed over the years, he mentioned that last month more than 4000 multi-cylinder engines were completed, and that the twenty-first birthday celebrations coincided with the completion of a combined extension and re-equipment scheme. This had increased the productive area of the factory and had raised the potential output to more than twice the current production. After brief reference to currency and other problems which restrict output, the chairman went on to say that the company was constantly endeavouring to improve tool utilisation and stated that the horsepower available to each productive work had increased from 2 h.p. to 6 h.p. in the last three years. After luncheon the guests were able to make a tour of the works to see something of the new production and also to inspect the many vehicles assembled, including a taxicab, buses, contractors' plant, road transport and agricultural equipment, all representative of the various applications of the Perkins engine as a power unit.

ALUMINIUM ALLOY CASTINGS.—We have received a copy of the *Proceedings* at a Symposium on Aluminium Alloy Castings, which has been published by the Aluminium Development Association, 33, Grosvenor Street, London, W.1. At the Symposium, which was held in Birmingham on November 6th and again in London on November 11, 1952, nine papers were read and discussed twice. The titles of papers included: "An Introduction to Aluminium Alloy Castings," "The Importance of Standards for Aluminium Alloy Castings," "A Survey of Some Researches on Aluminium Founding," "Developments in Finishing Aluminium Castings," "The Assembly of Aluminium Components by Welding," "Recent Developments in Aluminium Foundry Practice,"

The "Mechanicals" at Sheffield

DURING the latter part of last week the Institution of Mechanical Engineers held its Summer Meeting in Sheffield. It was attended by 412 members accompanied by 219 ladies. Counting in visits to a water board and a gas board, a power station and N.C.B. collieries, visits were made to forty-four firms. Though many of the members arrived in Sheffield on Tuesday, June 30th, and some of them attended a meeting of the Graduates' Section of the Yorkshire Branch at the Grand Hotel that night to hear a general discussion on "The Training of Mechanical Engineers," the meeting did not officially begin until the following day. On that day, Wednesday, July 1st, the members met in the Central Hall of Sheffield City Hall. They were made immediately aware of one of the customs of Sheffield. The welcome to such a party is offered by two men. The Lord Mayor speaks on behalf of the city; the Master Cutler on behalf of its trade. The Lord Mayor, Councillor Oliver S. Holmes, speaking first, as is customary, said that the president of the Institution, Mr. Roebuck, was trained in Sheffield and had carried out nearly all his work in the city. The city was proud that a man trained within its bounds had brought the Institution of which he was president to hold a Summer Meeting there. The Master Cutler, Sir Harold West, who was also chairman of the Reception Committee, said that after the project had first been put to the committee the problem had not been to find firms willing to entertain the visitors, but to reduce to manageable proportions the number of firms that wished to do so. That illustrated the pleasure with which the city welcomed the Institution members. It did so all the more in that few firms in the district did not number members of the Institution on their staffs. On behalf of Sheffield industries he welcomed the Institution to Sheffield.

In reply, Mr. Roebuck said that Sir Harold West had recently become a Companion of the Institution, a remark greeted by acclamation. The main reason, he supposed, why the Institution had come to Sheffield was that he, as president, was a Sheffielder. But whether or not that was so it was time that the Institution came there. Its last visit had been as long ago as 1890—and that to the fifth largest city in England! Earlier there had been a visit in 1861 when Lord Armstrong was president, and the meetings were held in the Music Hall in Surrey Street! But the names of those who on that occasion read papers before the members had since become household words amongst engineers and steelworkers. Mr. Roebuck then presented to the Lord Mayor and the Master Cutler, as mementoes of the visit of the Institution, inscribed copies of the book about the history of the Institution by R. H. Parsons.

At this stage the Lord Mayor retired from the meeting and the ladies—and some of the members, too!—left for a coach tour of the neighbourhood of Sheffield. Two addresses were then given. The first, on "The Mechanical Engineering Interests of Sheffield," was presented by Mr. M. A. Fiennes, and the second, on "The Metallurgical Industries of Sheffield," by Dr. Charles Sykes. Both were illustrated by many slides and between them they surveyed in a very interesting way the activities of Sheffield.

The members then divided up into parties to visit numerous works within or close to the city.

In the evening a conversazione and dance was held in the University Buildings, by invitation of the Yorkshire Branch Committee. Guests were received by Mr. C. J. Minter, chairman of the branch, and Mrs. Minter and by Dr. J. M. Whittaker, Vice-Chancellor of the University. The City Museum, which stands close by the University buildings, was opened to members and much interest was shown in its collections of cutlery and old Sheffield plate. But a small exhibition in the University itself attracted even more attention. In the physics laboratory there were displayed some historic engineering tools, a number of hand-made cutlery exhibition pieces, including penknives and scissors, the execution of which exhibited astonishing skill and ingenuity; an ancient set of hand shears, and maps, engravings, &c., illustrating the site and appearance, and method of operation, of old Sheffield iron and steel workings.

The whole of Thursday, July 2nd, was given over to visits to works, except that on the morning of this day the Automobile Division held a meeting in the Mappin Hall of the University, at which a paper on "The Manufacture and Properties of Automobile Suspension Springs" was read by Dr. C. J. Dodswell and discussed. Extracts from the paper appear elsewhere in this issue.

In the evening the Institution held a dinner in the Cutler's Hall. In proposing the toast of the "City and Trade of Sheffield," Sir George Nelson referred first to the fact that Mr. Roebuck was the first president of the Institution to be born and bred and work in Sheffield. It was true that it was sixty-three years since the Institution had visited Sheffield. But members of the Institution will recognised how much they owed to Sheffield and its production of steel. The Institution was jealous of its professional standards. By holding to and raising those standards it had perhaps contributed something to upholding the standards of Sheffield. He paid a warm tribute to Sheffield for its spirit and civic pride. Its work contributed to those British products of which they were all so proud. He had once been asked by an American why the British were able to achieve so much. He had answered that in Britain they did not sit on their laurels. They wore them—and in a different place!

In reply, the Lord Mayor remarked that Sheffield was a city they were all proud of and that it had much of interest to show the Institution. He believed, too, the ladies would carry away pleasant memories. That day he had had the pleasure of going round the works of the English Steel Corporation. The "dismal Jonahs" one sometimes heard ought to go round that works and see the activity the members saw! He was sometimes asked why did not industrialists take more interest in civic affairs? He felt the answer was that they had their hands full already with their own industrial affairs.

The Master Cutler, also in reply, spoke of the honour he felt in being made a Companion of the Institution. He went on to remark that although Sheffield contained several large firms it was not essentially a city of such concerns. Only twenty firms in Sheffield employed more than 1000 men and only 100 employed more than 250 and less than 1000. The small firms were controlled by men who knew their workers and worked beside them. As a consequence, though there were 40,000 steel workers in Sheffield there had been no serious strike in twenty years. Managements were close to their people. But that was essentially part of the teaching of an Institution that would not admit to membership any who had not worked on the shop floor.

In proposing the toast of "The Guests," the president said that the Institution now had 39,692 members, of whom 17,628 were graduates or students. It was a very encouraging and welcome fact that 18 per cent of those attending the Summer Meeting were graduate or student members. In his reply on behalf of the guests, Mr. Gerard Young, Pro-Chancellor of the University of Sheffield, referred to plans for the development of that University. The new buildings expected to be completed in 1954–1955 were all for engineering purposes. When they came into use they would have trebled the number of young engineers they could turn out each year.

Friday, July 3rd, was wholly given up to visiting firms, and the meeting was brought to a conclusion by the holding of a ball at the Town Hall by kind invitation of the Lord Mayor and Lady Mayoress.

Electricity for Horticulture*

By A. W. GRAY, A.I.E.E.†

In this paper the author considers electricity as a means of intensifying the development of the horticultural industry. He stresses the contribution that electricity can make to the basic processes of growing—by aids such as controlled space heating, soil warming, ventilation, plant irradiation, soil sterilisation and pest control. He visualises a potential connected load of about 700 MW and an annual consumption of 775 million kWh, mainly off-peak.

AGRICULTURE and horticulture are complementary, each playing its part in providing the essential foodstuffs for feeding mankind. There is, however, the basic difference that whereas agriculture is directed to the raising of products for subsequent processing before being consumed and so supplies our bread, meat and milk, horticulture is directed to the growing of produce for direct human consumption and provides the fruit and vegetables which are essential to a balanced diet. During recent years there has been some overlapping, and we find that the greater proportion of the main crop potatoes and some of the brassicas are grown on farms, but generally the definition applies.

What then is the size of the horticultural industry and what amount does it contribute to the nation's larder? The Ministry of Agriculture and Fisheries returns for England and Wales show that at June, 1952, there were 309,994 acres of land down to orchards and small fruit—raspberries, strawberries, currants, &c.—and that during the crop year ended June, 1952, 434,931 acres of vegetables and flowers were grown. The corresponding figures for 1953 are not yet available but it is anticipated that they will be materially the same and it is reliably estimated that the value of horticultural crops grown commercially in England and Wales for the crop year ended May, 1953, was approximately £114 million.

These figures may come as a surprise to many, but they are still more significant when related to the total horticultural requirements of the nation and these, excluding the produce from gardens and allotments, are valued at approximately £214 million per annum. Thus, with imports running at about £100 million per annum, the horticultural industry of England and Wales is only providing approximately 53 per cent of our annual requirements. This is far from satisfactory when we realise that our climate and soil are particularly suited to horticultural production and that we have to find goods or foreign currency to pay for produce

* Abstract: Paper, The British Electrical Power Convention, Torquay, June, 1953.
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which could be grown here at home and would then be of better flavour and quality.

What then is being done to deal with this problem to step up production to a point where we are independent of foreign imports and so make it possible for all to enjoy the high quality fruit, vegetables and flowers produced from our own land by the skill of our own growers ? Are we getting more acres into efficient production or what is more important are we stepping up output per acre ? Unfortunately, we are not, and what is even more alarming there is every indication that each year less and less of our horticultural needs will be met from home production.

Something must be done and done quickly to halt this decline of the horticultural industry, to ensure that the present level of production is maintained and to expand the output to the maximum. Higher prices will not help and the answer lies in increasing the overall efficiency of the industry generally and so cutting production costs to a point where it is economic for the grower to produce to the maximum of his holding and to gain and invest capital in the expansion of his business.

Electricity and electrical techniques can be of direct and considerable help in attaining this end in ways which are described in this paper. It can also ensure that the right kind of worker is attracted into horticulture by providing on the holding and in the rural homes those working and living conditions which electricity alone can give.

Lighting

One accepts as absolutely necessary a good lighting installation in the home, office and workshop and yet it is doubtful if on even 1 per cent of the commercial horticultural holdings in this country any attempt has been made to provide good working light in the various working areas. While we in the electricity industry must accept a large measure of responsibility for failing to make the grower more conscious of the value of good lighting it is remarkable that he himself has not fully realised the significant effect a good working light can have on the utilisation of his labour. This is particularly so during the winter months when so much work has to be done in glasshouse, potting and packing sheds, stokeholds and yards, and when the general grumble is that there are " too few hours of daylight " in which to get the many jobs done.

It is common to see workers in propagating houses and potting sheds endeavouring to perform such tasks as seed sowing and the pricking out of seedlings, which require considerable skill and attention to detail, with completely inadequate lighting ; and yet these are operations which unless efficiently carried out can have a most damaging effect on the quantity and quality of the final crop and consequently on the return to the grower. Failure to provide the best conditions under which to carry out this work can and often does mean both increased production costs and decreased returns.

There are many other ways in which a good lighting installation will pay high dividends : repairs to faulty implements and equipment urgently needed next day, grading, packing and loading produce ready for an early start to catch the morning markets are only some of the vital jobs which can be carried on as long as the job demands and not for just as long as daylight lasts.

Pest Control

The glasshouse grower, in common with all horticulturists and agriculturists is waging a continual war against pests and diseases, but strict hygiene is even more important in the glasshouse than for field type crops. Consequently, every year considerable sums of money and many hours of labour are spent on insecticide sprays and fungicide smokes. Quite recently, however, there has been developed an entirely new technique of dealing with this problem. Solidified insecticides and fungicides are placed in small thermostatically controlled electrically heated containers. Under the influence of the heat the insecticide liquefies and is given off into the air in the form of aerosols. These aerosols or particles are much smaller than those obtained from the average mechanical spray or low pressure atomiser, and remain suspended in the air of the glasshouse for a much longer time. The thermostatic control ensures that there is a steady production of aerosols, and consequently the insecticide or fungicide, whichever is in use, is doing its work the whole of the time, ready to deal with the troubles as they arise rather than waiting until they are established as is usually the case when smokes and sprays are manually applied. The electrical loading of this equipment is very small in proportion to the benefits which the grower derives from its use, but this is another service which only electricity can give to the grower.

Light Irradiation

Of all the factors governing plant growth light is predominant. The intensity of light provides the energy necessary for the conversion of plant food into plant tissue and so builds up the plant, and the hours of light, or day length controls the maturing of the plant. In its natural habitat a plant gets naturally the intensity and duration of light it requires and so produces its flowers and fruit in proper season, but horticulture to-day demands that a considerable range of plants must flower and fruit in countries where conditions of climate and light are very different from those of the country of origin and often at times of the year when the seeds or plants would normally be dormant.

Conditions of temperature and humidity sufficient to start the plant into growth can be provided in the heated glasshouse, but without the necessary intensity of light and length of day healthy growth and development is impossible. Horticulturists and horticultural scientists have been working on the problem for a number of years and now provide artificially the light conditions necessary for controlled plant growth, electricity being the immediate and indeed the only practical choice for this work.

Much research is being carried out on the control of flowering plants, but the major commercial application in this country is in providing artificially the light conditions essential for the healthy and vigorous growth of tomato and cucumber seedlings raised during December, January and February when the natural light is insufficient to meet the full requirements of the plants.

These plants are two of the few exceptions which are not responsive to day-length treatment, but they do need high intensities of light to provide the energy essential to the formation of plant tissue and research workers have established that supplementing the natural daylight by high intensities of artificial light has a most beneficial effect on the growth and development of the seedlings resulting in earlier cropping and some increase in the total yield.

The high-pressure mercury vapour lamp has been found to be the most suitable for this work since it gives a high intensity of light without excessive heat, which would be detrimental to the seedlings. The seedlings, pricked out into pots or soil blocks three to four days after germination are given twelve hours of supplementary light each day for approximately twenty-one days from pricking out, the plants so irradiated making up to three times the growth of plants not given additional light, fruiting up to three weeks earlier, giving appreciably higher yields during the early part of the cropping season and an overall increase in the total crop.

This response to light irradiation is of great importance to the grower and he can take advantage of it in two ways. He can plant his seed some three weeks later and so save space-heating costs for that period—a considerable item at that time of the year—while still picking at the usual time. Alternatively, he can start propagating at the usual time and commence picking some three weeks earlier when the market price of the produce is higher. Whichever course is adopted the grower will still derive the benefit of heavier yields during the early part of the season and the increase in total crop.

The h.p.m.v. lamps are mounted at 3ft from bench level, each lamp irradiating the seedlings placed pot thick on the bench over an area of 4ft by 3ft 6in—a total of 160 plants in 3½in pots or approximately 200 plants when in soil blocks. With the twelve hours per day treatment two batches of plants can be irradiated each day, the lamps being so arranged that they can be easily moved from one batch of seedlings to the other. Ideally, the changeover would take place at 12 mid-day and 12 midnight, but as the midnight changeover would necessitate staff remaining out of bed until that time the changeover is usually made before that hour. It should never be before 10 a.m. and 10 p.m. or one of the batches of plants will get less than the six hours of darkness essential for balanced growth and the nearer to midday and midnight the changeover is made the better. Three runs of light irradiation can be carried out during the season and when light irradiation is carried out in a glasshouse with thermostatically controlled space heating and on a soil warming propagating bench the maximum benefits will be ensured.

Advantage has also been taken of the effect of artificial light to grow tulips, daffodils and similar flowers in insulated buildings, using artificial light only ; the majority of the work on this application has been carried out in Holland, but a number of installations are now operating in this country with considerable success. The bulbs, which have previously been specially prepared, are brought from the standing grounds into the insulated buildings when the shoots are approximately 2in high, and arranged on tier-type benches, three tiers being installed in a 10ft high building. Each tier is separately lighted for a period of twelve hours in the twenty-four from tungsten lamps mounted at 3ft height from the bench and usually fitted to the underside of the upper tier. These are so spaced that a loading of 100W per square yard is provided. The resultant flowers are generally of excellent quality, ready for market several days before similar varieties grown in the glasshouse. In a well insulated building and taking into consideration the fact that three tiers of benches are used instead of the normal single bench in the glasshouse, the space heating cost per flower is approximately one-twentieth of that for similar flowers grown in the glasshouse. For this type of growing thermostatically controlled electrical heating is ideal, and with a time switch controlling the hours of running of the lighting, the grower need only pay visits to the building for the purpose of watering the flowers and attending to ventilation.

Another interesting development is in the use of fluorescent lighting for controlling the sprouting of seed potatoes. This is becoming quite common practice in Holland and one or two installations are already in use in this country. The seed potatoes are placed in trays and stacked one above the other to a height of approximately 9ft, the blocks of trays being a maximum of four trays wide. In the alleyways between the stacked trays and at intervals of about 7ft are strung vertically in tandem pairs of 40W " warmwhite " fluorescent tubes. These are so positioned that each pair of tubes is lighting the trays standing on a floor area of approximately 6 square yards.

The best results have been obtained where the lighting has been continuous and from the time of boxing, which is normally September until the end of February, although it is felt that further work may show that satisfactory results can be obtained if the lighting is restricted to twelve hours or so running in the twenty-four.

Where artificial lighting is provided the potatoes which require to be stored at a temperature of approximately 36 deg. Fah. are better stored in insulated sheds or cellars. This cuts out the need for supplying the space heating which is essential for frost protection when the seed potatoes are stored as hitherto in glasshouses. It is, however, necessary to provide ventilation in these insulated rooms and electric fans controlled by an air thermostat ensures automatic and trouble-free control.

Artificial lighting is also being used to control the flowering dates of some varieties of chrysanthemums. The plants of certain mid-season varieties when exposed to quite low intensity light, 10ft candles on the mature leaf—for a period of two hours during the night from mid-August to mid-September, flower some three weeks later than similar plants not lighted. As this work is extended it is hoped that it will enable growers to send a better range of varieties

to the market much later in the year than is possible without the use of artificial lighting.

Precooling of Bulbs

The progressive grower is always looking for means of extending the season of a particular crop and with bulbs this usually means trying to get a part of the flower crop particularly early. To this end a technique of conditioning bulbs for early flowering has been developed in Holland where many tons of bulbs are grown, treated and imported into this country each year for early forcing. During the last year or so, however, much of this treatment is being carried out in this country particularly with the tulip and daffodil bulbs grown in our own bulb fields. Insulated rooms for " precooling " are equipped with electrical space heating and refrigeration, both thermostatically controlled and an increasing number is being installed in this country each year.

The treatment consists of placing the bulbs in insulated chambers soon after they are harvested and holding them at a temperature of 70 deg. to 72 deg. Fah. for a period of fourteen days, the temperature of the store then being lowered to 48 deg. Fah. and kept at this level for six to nine weeks, depending on the variety of bulb being treated. On completion of the " precooling " treatment, the bulbs are ready for forcing and flower up to three weeks earlier than untreated bulbs, coming on to the market at a time when there is a scarcity of other flowers. Continued holding in a warm store will delay flowering and during recent experiments in Holland, home of bulbs and bulb treatment, bulbs have been kept dormant throughout one year and flowered to perfection more than eighteen months after being harvested.

Horticulture in Rural Electrical Development

The paper up to now has stressed the value and necessity of an adequate supply of electricity on the horticultural holding. Fortunately, a supply is available in many instances, but there are still a great number of holdings where it will be necessary to carry out either expensive mains augmentation or even provide new supplies to cope with the comparatively heavy demand which can be expected. This will cost a considerable amount of money and it is essential to consider first what revenue return can reasonably be expected to cover this capital expenditure.

The greater proportion of horticultural crops are raised in the open ground, but the most intensive growing is that carried out under glass protection in heated and unheated glasshouses and in frames under lights. Electricity can be of immense service to all branches of horticulture, but it is in these concentrated areas of glasshouses and frames that it has become an absolute necessity and it is to these that the electricity supply industry must look for the bulk of the revenue required to finance any major expenditure on rural mains augmentations and extensions.

Table I shows feasible load and consumptions for a holding having half an acre of heated glasshouses, two propagating houses and a quarter of an acre of dutch light frames and fully equipped electrically.

This estimated load and consumption on a relatively small holding is impressive enough, but the overall figures are even more enlightening. At July, 1952, the area of commercial heated glasshouses in England and Wales was 3918 acres with a further 701 acres of unheated glasshouses and 570 acres of frames, bells and cloches. Assessing these on the same degree of electrification as the example given in the table would show a connected load of 995,000kW and a potential annual consumption of 1209 million units. To this can be added 4kW per acre for ancillary equipment, refrigerators, shredders and mixers, &c., for staff-room equipment and to cover a certain amount of space heating, with a consumption of 1000kWh for each kilowatt of this equipment the total possible connected load and consumption from the protected cropping areas would be 1,016,000kW and 1230 million units.

Maximum electrification is, however, impossible to attain as this would not fit in with the crops and cropping routine in all nurseries, but it is feasible to visualise an ultimate electrification of 60 per cent of the total glass area and even this would provide a connected load of 610,000kW and a consumption of 738 million units per annum.

This, however, is only part of the picture, electricity is required on the " open ground " holdings for spraying, storage and processing equipment and for heating and lighting in offices and staff rooms, and this increases the total load and consumption considerably. There are 309,994 acres down to orchards and small fruit and a connection of only 100W per acre and a consumption of 250kWh for each kilowatt connected will add 31,000kW and 7¾ million units to this total. It is well within the bounds of possibility that the 434,931 acres on which vegetables and flower crops are grown call for a higher degree of electrification and 200W per acre with a consumption of 500kWh per kilowatt connected would provide a further 58,000kW of load with a consumption of 29,000,000 units.

The total feasible connected load and consumption is therefore :—

	Acres	kW	kWh
Protected cropping	5,189	610,000	738,000,000
Orchards and small fruit ...	309,994	31,000	8,000,000
Vegetables and flowers	289,954*	58,000	29,000,000
Totals	605,137	699,000	775,000,000

* To arrive at acres devoted to vegetables and flower crops it is assumed that 1½ crops per acre are grown—i.e. 289,954 acres by 1½—434,931 acres of vegetables and flower crops grown per annum.

The cost to the horticultural industry of the equipment excluding wiring and, therefore, sales by the electricity and allied industries would be approximately £19,000,000. This is a large sum of money, but the horticultural industry is one of high capital expenditure—the replacement value of the existing glasshouses and frames alone is at a conservative estimate, £45,000,000.

The engineer will ask : " What then is the load factor and what are the load characteristics ? " The load factor calculated on the connected load of the industry is, of course, low, being in the region of 13 per cent, but if we study the load characteristics we begin to appreciate the value of this type of load.

If consideration is given to the probable contribution of the glasshouse section of the horticultural industry to the December-January system peak load of the electricity supply system even the figures given in column 3 of Table I would give an annual load factor of 83 per cent. This is vastly superior to all consumers taken together (load factor on the system in 1951–52 was 47·4 per cent) but still does not adequately express the value of the load. The probable contribution to the annual system peak load of the representative holding covered by the table would not be more than 15kW on which the annual load factor would approach 200 per cent.

Taking the table as a guide it will be seen that only 21 per cent of the total load for the " Protected Cropping " section of the industry is " On Peak " and then only for short periods as the automatic controls will ensure that there is a good diversity and of the total units consumed approximately 95 per cent would be consumed during the night period or during the " unrestricted " months of the year. The case for the " open ground " load is every bit as good, far and away the greater part of the equipment will be used only during late spring, summer and early autumn and will offset to a great extent the " On Peak " and winter load of the " protected cropping " section.

This then is the picture of commercial horticulture and rural electrification, a potential connected load of nearly 700,000kW and a consumption of approximately 775 million units, much the greater part of which would be used during those hours of the day and those months of the year when the electricity supply industry is best able to supply it. Nationally, this is only a drop in the ocean, but as far as rural electrification is concerned this, coupled with the potential load and revenue from agriculture, might well mean the difference between unremunerative and restricted development on the one hand and thriving economic expansion on the other. The potential load and revenue is there—what are we going to do about it ?

Table I—*Typical Load and Consumption Characteristics of a Horticultural Holding*

Application	Total load, kW	Load on peak, kW	Load off peak, kW	Hours of running	Running characteristics	Period of year	Units on peak	Units off peak	Total units
Glasshouses :									
Prewarming	55	—	55	30 hours	Night only	Feb.	—	5,000	5,000
Maintenance warming	—	—	—	7 p.m.–7 a.m.	Night only	Feb./May	—	75,000	75,000
Forced draught unit	1	1	—	Unrestricted	Intermittent	Feb./June	200	800	1,000
Accelerators	2	2	—	Unrestricted	Continuous	Feb./June	600	2,000	26,000
Propagating house :									
Soil warming	10	10	—	Unrestricted	Intermittent	Oct./May	8,000	16,000	24,000
Accelerators	1	1	—	Unrestricted	Continuous	Oct./May	1,500	900	2,400
Light irradiation (10 lamp unit)...	4	4	—	Unrestricted	Continuous	Dec./Feb.	3,000	3,000	6,000
Dutch light frames :									
Soil warming	75	—	75	7 p.m.–7 a.m.	Night only	Nov./Apl.	—	135,000	135,000
General lighting	4	2	—	Unrestricted	Intermittent	All year	500	500	1,000
Soil steriliser	9	9	—	Unrestricted	Intermittent	Sept./Apl.	700	800	1,500
Water pumping	6	6	—	Unrestricted	Intermittent	All year	200	1,000	1,200
Totals	167	35*	130	—	—	—	14,700	240,000	254,700

* 35kW, shown as " On Peak," would be subject to diversity and simultaneous load measured over half-hour is likely to be much less.

American Engineering News

(By Our American Correspondent)

A Survey of the Engineering Profession in the United States

The Bureau of Labour Statistics of the U.S. Department of Labour has issued a report entitled *Employment, Education and Income of Engineers*, 1949–1950, which provides interesting data on the American engineering profession. The report is based on a survey which was made by the Engineers' Joint Council for the U.S. Department of Defence in an effort to create a register of qualified engineers in America. The survey included more than half of all institution members of full professional grade, a larger proportion than was covered by any previous Government survey. However, these engineers are believed to represent only about one-eighth of the entire engineering profession in the U.S.

In interpreting the findings in this analysis, it must thus be realised that the group considered was not representative of all the engineers in the country. To qualify for full professional membership in most American engineering institutions, an engineer must have reached a specified age (from twenty-six to thirty-five years, depending on the institution), and must have had a specified number of years of experience, including several in a position of responsibility. As a result of these membership requirements, there were relatively few persons under thirty-five among the engineers covered by this study, and the proportion varied among engineering fields.

The majority of persons covered by the report were employed in engineering positions. However, a small group (2 per cent of the total number reporting) were engaged in non-engineering work. even though they considered engineering to be their field of highest competence. Half of this group were engaged in scientific work ; the others were employed in a wide variety of non-scientific fields. The number unemployed at the time of the survey was insignificant. The proportion of engineers employed in each of the major branches of engineering was similar for the institution members surveyed and for the profession as a whole. In 1949, mechanical

engineering, as the largest branch of the profession, employed an estimated 150,000, or about two-fifths of all engineers. Civil engineering accounted for the second largest group—about 25 per cent. Other branches of engineering employed much smaller proportions of persons in the survey: electrical engineering, 15 per cent; mining and metallurgical engineering, 12 per cent, and chemical engineering, 7 per cent. The engineers approached by the Council were asked to indicate not only the kind of work on which they were employed, but the three fields of specialisation (in order) in which they considered themselves more competent. It was found the proportions of engineers employed in the different branches of the profession corresponded very closely with the proportions of engineers who regarded the given branches as their fields of highest competence. This held true not only for the major branches of engineering—chemical, civil, electrical, mechanical, and mining and metallurgical—but also for most sub-classifications.

It is evident from the report that most persons covered by the study were being utilised in the branches of their greatest knowledge and skill. There were, however, some exceptions to this rule. The small and growing fields of guided missiles and nuclear reactor engineering drew persons from other fields of engineering; they employed a considerable number of engineers who did not regard these specialties as their fields of highest competence. On the other hand, in aeronautical engineering, the number of engineers employed was smaller than the number with first competence in this field. Some persons who gained experience in aeronautical work during the last war had to transfer to other fields, owing to the post-war contraction in aircraft production. In view of the sharp expansion in this industry after 1950, the situation may since have been reversed, however. The fields which the engineers listed as those of their second and third highest competence give an indication of the possible supply of personnel which might be tapped if an imperative need for additional engineers should arise in a particular field.

The basic difference with respect to age between the surveyed engineers and the profession as a whole is shown by a comparison of average ages. Forty-five was the median age of the engineers covered by the report. In contrast, the median age of all engineers in the United States in 1949–1950 is estimated to have been under forty. The age distribution of the institution members contacted varied somewhat among the engineering branches. The groups with the lowest median age in 1949–50 (forty-two years) were the chemical and mining and metallurgical engineers. Mechanical engineers came next, half of them being forty-three years of age or over. The oldest were the electrical and civil engineers, their median ages being respectively forty-six and forty-seven years. To some extent, these age differences can be attributed to the variations in the requirements for full professional membership between the individual institutions. Thus, the American Society of Civil Engineers excludes from full professional membership all civil engineers under thirty-five years of age. On the other hand, the American Society for Metals, which counts among its members a large number of metallurgical engineers, admits to regular membership all engineers twenty-one years of age and over.

The employment of women has made very little headway in professional engineering work in America. There were only fifty-six women among the 55,000 established engineers covered by this 1949–50 survey. Some attempts are now being made to encourage the education and employment of women in engineering. As yet, however, it appears that there is practically no supply of trained and experienced women in this field.

With regard to educational background, the report indicates that 60 per cent of the engineers contacted held first degrees only. Twenty per cent had higher degrees—4 per cent the Ph.D. and 16 per cent the M.Sc. or equivalent degree. The remaining 20 per cent held no degrees and 7 per cent had never attended a college or university. In considering these figures it should be remembered that the standard of an American master's degree is generally considered to be equivalent to that of a British honours bachelor's degree. The small group of engineers with doctor's degrees obtained this degree in an engineering field in the majority of cases. However, two out of every five held doctorates in other fields. In contrast, all but 5 per cent of the baccalaureates and 12 per cent of the master's degrees were obtained in engineering. Because of the growing emphasis on post-graduate training for many fields of engineering work, it is felt that both master's and doctor's degrees are likely to become more common in the profession in the future. The report shows that fairly wide differences exist in the extent of post-graduate education among engineers in different branches of the profession. Chemical engineers lead in the proportion of doctorates held. In this survey the proportion of chemical engineers with Ph.D's was 14 per cent, compared with only 4 per cent of the mining and metallurgical engineers. Master's degrees, similarly, were held by a larger proportion of chemical than of other engineers. The groups with the lowest proportion of holders of higher degrees were the mechanical and civil engineers. More than 20 per cent of the persons in these branches did not have even bachelor's degrees. This was particularly true of the mechanical engineers, more than a fourth of whom had not completed a four-year college course.

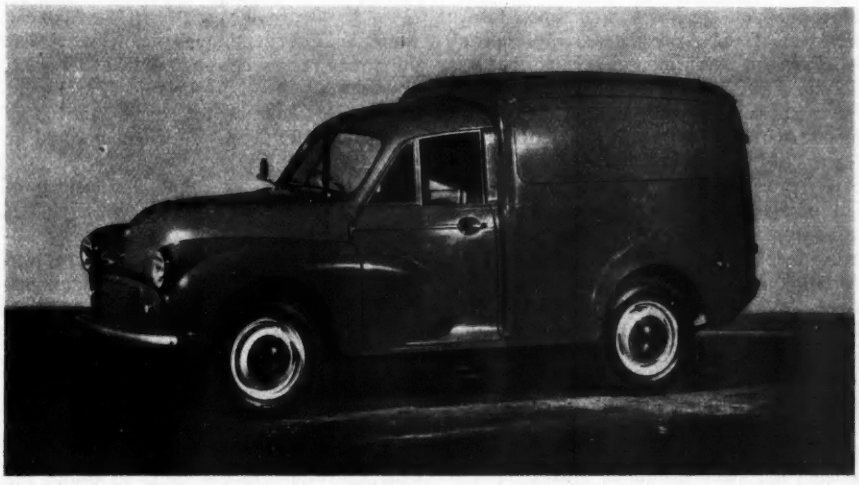
The principal function performed by each respondent was coded according to the following list: research, design, development, testing, procurement and sales, production, construction, operation, administration, teaching, and other. Design was the function performed by the largest group of engineers (22 per cent). The next largest group (15 per cent) were doing work classed as operation. The third largest number (13 per cent) were chiefly engaged in administration. Every other function in the list was reported by fewer than 10 per cent of the respondents.

Since 1943, the last previous year for which income figures were available, the earnings of engineers have increased considerably, as have incomes in general throughout the United States. In 1943 members of engineering institutions who were thirty-five years of age or over had a median income of 5900 dollars, whereas engineers aged thirty-five or over in the present survey had a median income of 8100 dollars. This represents an increase of approximately 37 per cent. Over the same six-year period living costs in the United States, as measured by the "Consumers' Price Index for Moderate-Income Families in Large Cities," also increased by approximately 37 per cent.

In interpreting these income figures it must be noted that they are based on information collected in the second half of 1949 and the first half of 1950, and earnings are known to have increased considerably since that time. It is of particular interest to note that earnings tended to be considerably higher than the average in certain branches of engineering. The highest median incomes were found in chemical engineering (9000 dollars for all men thirty-five years of age or over) and in "other" engineering (9100 dollars). The branch with the lowest overall median income (7100 dollars) was civil engineering. These differences can be explained, at least in part, by the history of each field as related to the demand, supply, and utilisation of personnel. For example, the especially high earnings of the older chemical engineers may reflect the fact that, during the expansion in the chemical industries which began during the first world war, engineers with training in this field were scarce and often obtained promotions early in their careers. Among the civil engineers in this survey the rise in income levels with age was much less than for persons engaged in any other major branch of engineering. This difference undoubtedly reflected the large proportion of civil engineers employed by Government agencies, where there have always been fairly rigid ceilings on salaries, and where salary scales are much less flexible in response to changing economic conditions than they are in private industry. The respective median incomes for men thirty-five and over were as follows:—Self-employed (employer or owner of business), 14,700 dollars; self-employed (independent consultant), 10,700 dollars; private industry, 8400 dollars; educational institutions, 7100 dollars; Government employee, 6600 dollars.

A New ¼-ton Van

A NEW Morris ¼-ton van has been announced by the Nuffield Organisation. This model, equipped with the British Motor Corporation 800 c.c. overhead valve power unit and independent front suspension with torsion bars, has the performance, road-holding and comfort characteristics of the Morris "Minor," on which it is based. In addition, the van body has a capacity of 78 cubic feet (2·2 cubic metres) with an extra 12 cubic feet (0·34 cubic metres) of space available beside the driver. The van is to go into immediate production and will be available on both the home and export markets, either with an all-metal van body, an all-metal pick-up body (with or without the canvas tilt) or in chassis/cab form (the cab back panel being an optional fitting).



Morris ¼-Ton Van

"ECONOMY" OVERDRIVE.—We are informed by the Nuffield Organisation that Morris Commercial Cars, Ltd., has developed a new overdrive system which saves up to 10 per cent in fuel consumption and increases engine life without reduction in road speed. This overdrive, which is fitted as standard without extra cost, reduces engine revolutions by almost 20 per cent so that, for example, the engine speed of a 5-ton vehicle travelling at 30 m.p.h. will be reduced from 1910 to 1541 r.p.m. without loss of speed.

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THE HARROW ACCIDENT AND A.T.C.

Major disasters on the British railways by their very rarity never fail to arouse feelings of particular horror, and for some little time afterwards the burden of many letters in the national and in the technical press is to seek means whereby "it could never happen again." Sometimes, as in the case of the Armagh runaway collision in 1889, the public conscience has been so deeply stirred as to secure the adoption of increased safety measures by Act of Parliament; but those who have studied the reports of the Government inspecting officers over the past forty to forty-five years cannot fail to have noticed the frequency with which some form of automatic train control has been recommended. In retrospect, those officers appear to have been little more than voices crying in the wilderness. But now the catastrophe at Harrow last autumn appears to have done for A.T.C. what Armagh did for automatic continuous brakes, and for the absolute block system; and the British Transport Commission is now prepared to consider financial authority for a scheme that will eventually cost some £17 million. Although quite a number of different schemes were put forward in the days before the grouping of the railways in 1923, only two companies, the North Eastern and the Great Western, tackled the problem on any scale. When the former company became part of the London and North Eastern the cab signalling system so energetically and successfully developed by Sir Vincent Raven was carried no further and the apparatus eventually removed. The Great Western, on the other hand, developed its own system to a high degree of reliability, and extended it until, eventually, almost every locomotive on the line was equipped. But until the sitting of the Pringle Committee of 1927 there was much conflicting thought on the subject. Railway officers were by no means in agreement as to what degree of control and what additional indications should be provided. The spectacle of elaborate systems introduced in America, in some cases extending to automatic control of train speed in accordance with the wayside signal indications, merely served to complicate the issue in Great Britain. The report of the Pringle Committee, however, established the principles of the Great Western system of warning control as something that might be generally adopted. But while those principles were accepted only the Great Western itself went ahead with the equipment of its main lines. The other companies considered that the great expense of installation would scarcely be justified in view of the small number of accidents which it was anticipated would be prevented.

It is at this stage that the history of British A.T.C. enters upon a phase that is perplexing to the layman. The London Midland and Scottish, and the London and North Eastern Railways showed some interest in the Hudd system of warning control; but experiments went forward no more than slowly, until the installation, in 1937, on the London Tilbury and Southend section and the equipment of 150 locomotives. This was, in effect, another way of achieving the same result as that given by the G.W.R. system except that, to quote the Harrow report, the audible signals "are not nearly so distinctive as the siren and bell of the Great Western system." It might then be asked as to why it was necessary to devise a different system at all, when the Great Western provided the additional warning that was generally accepted as desirable, and had done so with consistent reliability over a period of nearly thirty years. Simple though the Great Western arrangement is, however, the engineers of other railways favoured a more modern form of electrical pick-up than a contact ramp, and experiments continued. The disastrous collision at Castlecary, on the Edinburgh to Glasgow main line of the L.N.E.R. in 1938 spurred on the joint work of that company and that of the L.M.S.R., and but for the outbreak of war in 1939 the line between Edinburgh and Glasgow would have been equipped on the Hudd system. Between the end of the war and the nationalising of the railways two further serious accidents had occurred, at Bourne End on the L.M.S.R. in 1945, and at Goswick, on the L.N.E.R. in 1947, and the reports on both of them stressed the need for A.T.C. The assumption of control by the British Transport Commission in 1948 naturally brought to a head the divergencies in view between the former railway companies on the subject of A.T.C., and at that date the former G.W.R. had 1356 miles of route equipped with the contact system, while the L.M.S.R. had 37 route-miles equipped with the Hudd.

The Railway Executive were thus faced with a decision on the system to be adopted. The L.M.S. system was unacceptable, as it stood; on a long-term basis, envisaging the spread of electrification, the Great Western system also had some drawbacks. A blend of the best features of both became the policy of the Railway Executive, and the stages of development are described by Colonel Wilson in that part of the report on the Harrow accident which we reprinted last week. The experiments with the new apparatus are now in an advanced stage, but it is important to notice the emphasis laid by the Chief Inspecting Officer on the principle that the audible signals received in the engine cab should always be regarded as supplementary to the wayside signals, and never as a substitute. Thus, he considers that from the safety point of view there is no need for differentiation on the footplate between the yellow and the double-yellow indications at a four aspect signal. With regard to the present tests, on the successful results of which depends the launching of the large programme of A.T.C. installation on British Railways, it seems strange that a purely steam route, between Barnet and Huntingdon, should be chosen. One of the objections to the Great Western system is stated to be the risk of false indications by stray earth currents on lines electrified either with conductor rails or with overhead wires. Might there not equally be some similar risk with the inductors of the prototype system now on trial? Before the new apparatus is finally accepted as the future national standard it would surely be wise to extend the trials to cover electrified routes. The Southern main line between Waterloo and Woking, and the Eastern between Liverpool Street and Shenfield would provide the necessary experience with conductor rails and overhead wires, respectively, and both routes carry an exceptionally heavy and fast traffic. In view of the public anxiety following the Harrow disaster we appreciate and applaud the urgent desire of the Railway Executive to go ahead; but the new system must be proved beyond any doubt. There must never be the chance of wrong indications.

SHEFFIELD

Sheffield is a city about which more than one opinion can be held. The more cynical will say that its sole redeeming feature is the ease with which the visitor can get out of it into the spectacular country of the Peak District! For, it can seem a grim city when, as often happens, a drizzle of dirty rain falls and it is enveloped beneath the pall of smoke that so often lies over it. But, in truth, even to the casual visitor who has no special reason for being there, Sheffield

can prove a much more interesting place than the outward appearance of its wider streets suggests. For Sheffield proves upon closer acquaintance to be a city of courts and culs-de-sac, and many a seeming front door actually gives access not to a home, but to a little courtyard. Nor can the curious, penetrating into such places, ever be certain what he will find there ; whether it will be the dull, if decorous, offices of a solicitor and commissioner for oaths or some little business or workshop making some oddity amongst the many things that are made so skilfully in Sheffield.

To engineers, of course, Sheffield has a special appeal. For here is a city within which are produced the fundamental things of engineering. Steel is made in many parts of this country. But it is peculiarly to Sheffield firms that engineers look for the special steels upon the availability of which so much modern design depends. It is again to Sheffield that engineers turn so much for the cutting tools and hand tools of many kinds without which metals and other materials could not be machined or hand-formed to shape. From the railway as they enter the city engineers can peer fleetingly into workshops within which, excitingly, heated metal glows under the press or the hammer; and so far into the centre do workshops reach that one of Sheffield's best known hotels overlooks the shops of two companies whose products are famous the world over. It is therefore not at all surprising that Sheffield should have been chosen as the venue, this year, of the Summer Meeting of the Institution of Mechanical Engineers, and even less surprising, if that be possible, that its president, Mr. Roebuck, should have brought its members there. For Mr. Roebuck was born and bred in Sheffield, and has spent his life working there, a fact emphasised during the meeting when a party of members visiting Hadfields, Ltd., saw a presentation made to him by the firm as a memento of his fifty years of service. What is surprising is that it is well over sixty years since the Institution held a meeting in Sheffield, in 1890. Perhaps in the intervening years there were amongst the Institution's presidents none whose major interests lay in or around the city. Yet it would be a strange coincidence if there were not. For as the members found there is much more made in and around Sheffield than special steels and cutting tools alone. Maybe there is less variety of industry there than in other cities that the Institution members have visited, for the work of Sheffield centres around steel, its making, its working, its treatment and its fabrication. Yet even should this concentration upon steel begin to pall, there still remains for mechanical engineers the interest in the mechanical machinery by whose aid the work is done. Sixty years should not be allowed to pass before the Mechanicals again visit Sheffield. For though some of the Summer Meetings held by the Institution since the war have proved less successful than the Council hoped, about the success of the Sheffield meeting there cannot be two opinions.

During and since the war the Institution of Mechanical Engineers has grown greatly in power, prestige and authority until it is now, far more than it was before the war, a great national body. Furthermore, through the wise decisions of its Council, it has formed links with similar bodies throughout the Commonwealth, in America and upon the Continent of Europe. Yet ever since the war it has acted, by holding its Summer Meetings at home, as though it were still the small and intimate society of engineers it once was. Not once since the war, by taking its members abroad, has it shown a recognition of the importance of engineering production in Western Europe. Indeed, it is not since 1932 that it has gone abroad at all and not since 1922 that the members visited the Continent. Yet the industrial areas of Holland, Belgium and Northern France are no further off for many members than those of Scotland; and the industrial Rhineland is little further away. It is with firms in those areas, as much as amongst themselves, that British engineering firms compete for exports. For our part, therefore, despite the obvious success of the Sheffield meeting, we feel that the Institution has been failing in its duty in giving its members no opportunity to see how firms upon the Continent, firms having problems of design and production similar to those faced in this country, are setting about their work. There is, on the Continent, we know, for we have visited some of those firms, a great deal of engineering interest to be seen and not a little to be learned technically. There are, of course, in organising a visit, difficulties of currency, travel and language to be overcome. But other societies, notably the Iron and Steel Institute and the Institution of Naval Architects, regularly overcome them. Nor do we think the venture would lack support from members. For, even more surely than when a Summer Meeting is held at home, one held abroad is demonstrably educative. We hope and believe that every far-sighted firm would, therefore, prove willing not only to release executives and its younger men for the period involved, but also to regard the experience as valuable enough to justify the meeting at least of part of the cost. We believe that the sooner the Institution takes its members abroad the better, and, since organisation will take many months we hope that a decision so to do will soon be made. " For what should they know of England who only England know ? "

Literature

Ferrous Analysis : Modern Practice and Theory. By E. C. PIGOTT. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 84s.

THIS is a completely revised and greatly enlarged edition of a book, published in 1942 under the title *The Chemical Analysis of Ferrous Alloys and Foundry Products*, which soon became recognised as a standard textbook. The present edition is divided into five sections with appendices. The first section deals with available techniques and their choice. A very great number of physical and physico-chemical methods have now supplemented or replaced standard gravimetric or volumetric analysis, and these are classified in tabular form with indications of their principal fields of application and sources of error, with an estimate of their sensitivity, precision, time taken, cost, &c. Photo-electric absorptiometry and spectrographic procedure are dealt with in greater detail, and a summary of the application of organic reagents in the analysis of iron and steel serves as a useful review of the widely scattered information on this subject.

Section II (occupying 70 per cent of the text) deals with thirty-one elements possibly present or intentionally added to iron and steel. There are full accounts of methods of determination of the gaseous elements, oxygen, hydrogen and nitrogen. Antimony, of which small amounts may sometimes be present in steel, is not included, but receives mention in Section IV, where six lines only are inserted between " The Analysis of Aluminium Metal and Aluminium Alloys " and " The Analysis of Brasses and Bronzes," two subjects which find an unexpected place in a book entitled *Ferrous Analysis*. For each element in Secion II, information is given under the following headings :— " Physical Properties," " Extraction," " Ferrous Properties " (i.e. the influence of the element on the properties of ferrous materials and its application in steel metallurgy), " Chemical Properties," " Detection," " Consideration of Methods," " Determination," " Theory of Methods," " Bibliography."

Micro-chemical analysis is the subject of Section III, which includes " spot tests " (also referred to under the individual elements in Section II), micro-chemical identification of inclusions and macroscopic printing methods. The remaining sections deal with ferro-alloys, iron ores and refractory materials.

As may be judged from the amount of space it occupies, the outstandingly valuable portion of the book is Section II. For every operation a list of reagents, and the actual analytical procedure are clearly set out with a statement of the time required, and accuracy to be expected, and this is supplemented by a discussion of the theory of the method, including warnings against possible interference caused by the presence of other elements. A substantial part of the text is occupied by metallurgical information of a non-analytical character. As the author admits, its inclusion raises a controversial issue ; but he is fully justified in regarding it as legitimate when it affords guidance on choice of method or interpretation to be placed on the results of analysis. Metallurgical chemists engaged in analytical work should undoubtedly be aware of the effect of the various constituents and the proportions in which they are usually present for different applications. The accounts of " Ferrous Properties " are always interesting and sometimes extensive, but in a few places they do not conform to the criterion that the author lays down. For example, blast-furnace reactions (page 216), or the fact that steel was made in early times in India, and what Huntsman did in 1728 (page 218), have no direct influence on the interpretation of present-day analyses. The space could be utilised to more advantage by giving typical analyses of products of the modern blast-furnace, and of acid and basic, open-hearth, Bessemer and electric furnace steels to serve as a guide to recognition of the steel-making process involved. It is surprising that

microscopy, which is probably the most valuable adjunct to chemical analysis, is mentioned only once (in a table), though sulphur printing is described, structure and constitution are referred to under "Ferrous Properties," and some of the micro-constituents of steel are defined in an appendix. Micro-structure and a hardness test would go much further in interpreting the results of analysis than some of the more discursive comments that find a place in the book.

Though this is a revised edition, the text could still do with further revision to correct some obvious mis-statements and misprints. There is, however, no doubt as to the value of the book to all those concerned with ferrous analysis, and a tribute must be paid to its extensive range and general accuracy. Rapid methods of analysis of bath samples are classified. Choice of procedure is facilitated because the scope and limitations of each analytical method are discussed. Attention is directed to the increasing use of physico-chemical techniques. Workers in laboratories where standard methods of analysis are already well established will benefit by the author's exposition of underlying principles and appraisal of alternative procedure, and even the most experienced and well-informed analysts are likely to learn something from the author's comments, based on a classified bibliography containing more than 1000 references, summarising, for each element, all procedures published since 1930.

A History of Civil Engineering. By HANS STRAUB (translated by E. Rockwell). London: Leonard Hill, Ltd., 9, Eden Street, N.W.1. Price 25s.

THE history of civil engineering is often considered to be a rather neglected subject; a historical approach is rarely used in this country in teaching engineering students, and historical works on civil engineering are mainly confined to biographies of famous engineers. The translation of Mr. Straub's book into English therefore makes a welcome contribution to this subject.

The author states that his first preoccupation was to form a broad picture of the origin and gradual development of structural analysis, and the treatment of that subject is undoubtedly the most absorbing part of the book, and makes an interesting comparison with the recent paper presented at the Institution of Civil Engineers.* Other subjects, however, are not neglected. The first two chapters deal with engineering works of ancient and medieval times, and the evolution of the building techniques of the Renaissance and of the theories of statics and strength of materials is then discussed. There are then chapters on the advent of "civil engineering" and the origins of structural analysis, followed by an account of the effects of the industrial revolution on civil engineering, and of civil engineering during the nineteenth century. The last chapter discusses contemporary practice.

It is stated that the book is "addressed to students and practical engineers as well as to a wider circle of laymen." Presumably for this reason, and also on account of the extremely wide field covered, detailed accounts of the engineering technicalities of a particular structure or theory are given only in a few cases. Such detail is, to the technical reader, probably the most interesting aspect of historical study. The volume is not free, therefore, from the criticism which may be made almost without exception against any work addressed to both laymen and specialists, that in places it is too complicated for the former, and in others too superficial for the latter. One other criticism may be mentioned: it appears that some of the technical terms have been more or less literally translated, so that, although they are generally not likely to lead to error, the meaning may be a little obscure.

As a general summing up it may be said that a pleasant and interesting account of civil engineering history has been given, such as will profoundly interest the average engineer. Civil engineering history as it is commonly known here, tends to be rather insular in its content, and it is particularly interesting to see so many Continental examples of early structures and achievements. Amongst those cited, the detailed description of the first recorded application of structural analysis—to the dome of St. Peter's, Rome—is of exceptional interest, as is the mention of an arch bridge with a span of 236ft and a rise of nearly 70ft, built in 1370–77 over the River Adda at Trezzo.

Metropolitan Water Board: Fifty Years' Review, 1903–1953. London: Staple Press, Ltd., 14, Great Smith Street, S.W.1. Price 15s.

THE occurrence of the Metropolitan Water Board's fiftieth anniversary was noted in these columns earlier this year (THE ENGINEER, April 3, 1953), when a brief account of that body's history and development was given. Last year also, we printed an abstract from Mr. H. F. Cronin's presidential address to the Institution of Civil Engineers (THE ENGINEER, November 7, 1952), which gave some interesting facts about the Board's engineering activities. Many of our readers will therefore be to some extent familiar with the subject matter of the volume under review, which has recently been issued by the Board.

A very full account of the history and operation of the Metropolitan Water Board is given in its pages. All the various problems of London's water supply during the past fifty years are dealt with, covering the historical background, the finances of the Board, engineering schemes and problems, water examination and treatment, and the various legal and parliamentary aspects of water supply. The Board's activities during the second world war form the subject of one chapter.

* "The Historical Development of Structural Theory," by Dr. S. B. Hamilton. *Proceedings of the Institution of Civil Engineers*, Part III, December, 1952, Vol. 1, No. 3.

Printers of "The Engineer"

EVER since publication began in 1856 this journal has always been printed by the firm of George Reveirs, Ltd., save only for a short period in the early days of the war when the work was done by William Clowes and Sons, Ltd., at Beccles, in Suffolk. Even then, however, as a consequence of the arrangements made at the time, a number of Reveirs's men continued to take an important hand in the work. Over that long span of years there has grown up between the editorial and managerial staffs of this journal upon the one hand and the directors and workpeople of Reveirs on the other, an affectionate regard that triumphs easily over the various irritations and troubles inseparable from publication. We feel, indeed, almost as deeply interested in the future of George Reveirs, Ltd., as those who work for that firm. As from July 1st George Reveirs, Ltd., has become one of the firms within the Eden Fisher group of printing companies. We learn that the continuity of the business of the firm will not be affected by the change. But for reasons of health, which have for some months been giving anxiety to his friends, Mr. G. Leopold Reveirs is to give up the heavy duties of managing director though retaining his directorship. Those duties will be carried out by Mr. H. W. Underhill, managing director of the Eden Fisher group. We wish the firm a prosperous future under the new arrangement.

Letters to the Editor

We do not hold ourselves responsible for the opinions of our correspondents.

THE TRAINING OF ENGINEERING DESIGNERS

SIR,—In his letter printed in your issue of June 5th, Mr. F. P. Frost discusses how it could be arranged for industrial designers to play a part in the teaching of design at the universities. He rightly emphasises the importance of attention to the details of design, but perhaps underestimates the value of problems "beyond the students' experience." The labouring of detail throughout a three-year course is more likely to discourage than to stimulate the interest of students. If enthusiasm for design is to be stirred up, the problems of at least the last year should provide scope for the exercise of imagination. It may be, in fact, that it is by providing engineering faculties with currently interesting problems of this sort that industrial organisations could most effectively help to stimulate interest in design, and, at the same time, "sell" the idea of an industrial career.

As Professor M'Ewen has remarked, the devising of realistic assignments can be a heavy burden for faculty staffs. Expanding industrial organisations, however, would be in a position to select suitable problems from among those for which their own design departments have already produced working solutions. All the data required to provide a self-contained exercise should therefore be at hand, and at the end of the session the industrial designers concerned should not find the task of critical examination of the students' solutions too onerous; they might even find it rewarding!

I believe there would be many advantages, social as well as technical, in making this third year project a group exercise, with no examination marks for individuals. There should be no external direction of the group, the organisational, design and draughting work being shared inside the group according to the abilities and interests of its members. An element of control would be provided by the holding of regular design conferences attended by members of the faculty staff as consultants. At such conferences would, to use Sir David Pye's words, be reproduced "the atmosphere of discussion and compromise" of the design office, and here also would be an excellent opportunity to study the effectiveness of individual students under conditions less abnormal than those of the examination room.

A design exercise of this type has been successfully developed at the Royal Military College of Science. There is no doubt about the intense interest and the imaginative efforts it evokes from the students; those members of the faculty staff directly concerned are kept well on their toes throughout the exercise!

JOHN L. HOPKINS

West Hartlepool,
June 20th.

SIR,—The conjunction of the articles and letter on pages 884, 885, 886 and 889 in your issue of June 26th, bearing on the general theme of educating and training engineers, was a peculiarly happy one, following the recent report in your columns of the lecture by Professor M'Ewen. Commander Tracy's account of the "basic engineering" course provides an admirable postcript to the theoretical statements in the previous pronouncements on this subject.

One thing at least has emerged from the experiment in engineering design, namely, the important part played by experience in achieving successful design projects. As the present writer has stated in a former letter, while university training can prove helpful in teaching principles and theory, it is in the post-graduate period that real progress is made. It is during this period

that the student is in a position to demonstrate whether or not he has the flair for the job. The designs submitted in the team competitions served to show how important a part experience plays in producing soundly designed work. It seems logical, therefore, to assert that, while the training of designers may be begun in the university, continued in post-graduate courses, it is only after considerable acquaintance with materials, methods and machinery that the would-be engineering designer is able to make a worth-while contribution to industry. In passing it is worth pointing out that an elementary knowledge of design underlies general drawing-office procedure, but the faculty for design work is something distinct. While this may be taught, more often it is a trait which one has or has not.

S. C. McKENZIE

Rugby, Warwickshire,
July 3rd.

SIR,—I have read with great interest, not to say envy, Commander Tracy's article in your issue of June 26th. There is, of course, no question that design must always have production in mind and the combination of " design and make " he describes must be a salutary lesson to all who undertake it. It seems to me, however, that it is not ever likely to be practicable in undergraduate university engineering courses to go beyond the working drawing stage, which was the point I envisaged reaching : the burden on the workshops facilities of trying to go further would be excessive and I expect that the cost would be far beyond our means. If we were to follow the R.N.E.C. lead it would, I anticipate, only be feasible for a very limited number of post-graduate students. Nevertheless, the development of such post-graduate courses in design and production engineering is an end worthy of much effort to attain.

There is the possible compromise of making only one of the designs prepared, if undergraduate designs were run on Commander Tracy's lines ; but this would almost certainly be unsatisfactory in practice and in any case the real value of his method is that the students have to make the very articles which they have themselves perpetrated on paper.

There is only one point on which the R.N.E.C. practice appears a little questionable : designing and (presumably) tooling for 100 off and then making one off. Clearly it is difficult in fact to arrange to make more than one so that the merits of planning on so large a batch are not altogether apparent. Moreover, the principles of large quantity production will have to be expounded theoretically in any case, so why not reduce the planned quantity ?

Finally, although something on the line of Commander Tracy's course is an ideal for all, we must first restore design to its rightful place in the undergraduate curriculum even if the test of manufacture is missing and a critical instructor has to deputise for the irate works manager !

EWEN M'EWEN

King's College, Newcastle upon Tyne,
July 6th.

DISTRIBUTION OF PRIMARY NICKEL.—The manganese-nickel-cobalt committee of the International Materials Conference has announced acceptance by member governments of a plan of distribution for primary nickel and oxides in the third quarter of this year. The recommended plan has been forwarded to all interested governments for implementation. It is stated that in this plan, as in all those which have been recommended by the committee since the third quarter of 1952, provision has been made whereby any nickel allocated to countries participating in the distribution, but not used by them, will become available for purchase by consumers in the U.S.A. and in other countries. The quantity of primary nickel which is allocated under the recommended plan amounts to 36,315 metric tons. The comparable figure in the second quarter was 36,675 metric tons. Although the amount of nickel available for distribution in the third quarter is lower than in the second quarter, it has been possible to maintain the allocations of most countries at or near their second quarter level.

Summer Meeting of The Institution of Electrical Engineers

THE Summer Meeting of the Institution of Electrical Engineers was held, last week, in the North-Eastern Centre of the Institution, which covers the counties of Northumberland, Durham and Cumberland and the Cleveland district of Yorkshire. Many changes have taken place in this territory since 1927, when the Summer Meeting was last held there, but there has been no change in the capacity of the North-Eastern Centre to offer its visitors a pleasing blend of entertainment and instruction.

In its four-day programme, based on Newcastle upon Tyne as headquarters, the Summer Meeting included a variety of sight-seeing tours, social functions and technical visits which contained something to cater for all tastes and moods. There was, for example, a motor-coach excursion on Tuesday, June 30th, to Hexham Abbey and the Roman Wall. Another excursion on Thursday included the Border Country and Kielder Forest, which has a total area of 110 square miles and is the largest afforestation scheme upon which the Forestry Commission is at present engaged. The whole of this area is in Northumberland, covering the upper valley of the North Tyne ; 64 per cent of the area involved in the scheme is classified as plantable and more than 45 per cent is already planted. For the benefit of the more serious minded members who preferred to take part in the technical visits on Tuesday and Thursday, these two coach excursions were repeated in modified form on Friday.

In any event, the twenty-nine technical visits provided an almost embarrassingly wide choice, including, for instance, two collieries, a glassworks, three electrical and steam plant manufacturers, a cigarette factory, a shipyard, two iron and steel works, a manufacturer of automatic telephone exchange equipment, two chemical works, two cable works, a flour mill, an electricity substation, and three power stations. It was not possible for one member to visit more than a very limited number of these works and installations, and some reference to those that we saw is made below.

The Summer Meeting opened with an informal reunion at the Royal Station Hotel, Newcastle upon Tyne, on Monday evening, June 29th, when members and their ladies foregathered to renew old acquaintances and make new ones. Short speeches of welcome were made by the Lord Mayor of Newcastle upon Tyne, and by the president of the Institution, Colonel B. H. Leeson, who, it may be recalled, has an association of long standing with the electrical manufacturing industry in Newcastle.

On Tuesday morning we visited the Heaton works of C. A. Parsons and Co., Ltd., where the manufacture of steam turbo-generating plant and transformers is carried out in a works extending over some 55 acres and employing nearly 6500 people. A comparatively new activity in these works is the production of high-pressure and low-pressure pipework, an enterprise which was started in response to the urgent demands created by the post-war programme of power station expansion. For this purpose C. A. Parsons and Co., Ltd., established a new pipe division —a self-contained manufacturing organisation, consisting of three large shops, with its own design and drawing-office, its own fabrication, welding and machine shops, and the associated stores, inspection, records and dispatch facilities.

Our visit began, appropriately, in the new administration, research and drawing-office building, the spacious entrance hall of which is designed and laid out as a memorial to Sir Charles Parsons. It contains a number of show cases exhibiting many of the original pieces of apparatus used by Sir Charles in his experimental work. The main portion of this building is devoted to design drawing-offices in which particular attention has been devoted to the attainment of a very high standard of lighting. The result is an outstanding example of applied illumination, using an installation of continuous strip fluorescent tubing in metal trough reflectors, similar to that described in our issue of Dec. 12, 1952, page 810.

This new building houses a piece of equipment of unusual interest—a heat flow analyser, consisting of an electrical analogue for simplifying the complex mathematical analysis involved in the calculations of heat flow between different parts of a steam turbine. The electrical analogue consists of an arrangement of variable voltage sources, corresponding to temperature differences, variable resistors corresponding to resistance to heat flow, and variable capacitors, corresponding to heat capacity. These components are installed in banks flanking a control desk and they can be simply connected up to simulate their analogues in any particular heat flow problem. The current can be measured in any part of this network and its value gives a measure of the heat flow in the corresponding part of the turbine rotor or other part that is being investigated.

In the afternoon we visited the works of A. Reyrolle and Co., Ltd., Hebburn-on-Tyne. Our tour began in the New Town Works, where we saw the new a.c. network analyser which the company has installed for the study of power station problems, such as load distribution, voltage regulation and synchronous stability. In its general design this analyser is conventional except that the base frequency, 1592 c/s, is much higher than usual, to facilitate the study of some higher frequency phenomena such as rates of rise of restriking voltage. Another interesting detail is that the equipment includes an automatic mimic diagram and check metering facilities whereby the arrangement of the component quantities set up, and the metered quantities, can be checked.

At the Hebburn Works switchgear of various kinds and ratings up to 275kV were seen in course of assembly and typical examples of finished panels had been erected for inspection. These panels included a direct-hand-operated 11kV, 150MVA, oil-break circuit-breaker panel on which the general principle of horizontal draw-out, metal-clad switchgear could be demonstrated. There were also examples of metal-enclosed, air-break circuit breakers of both single and duplicate busbar construction rated at 3·3kV, 150MVA. We also saw a 33kV, 1500MVA horizontal draw-out, metal-clad unit on 4ft 9in frame centres and a number of small oil volume circuit breakers of ratings up to 220kV and 5000MVA. A sectioned single phase of a 132kV circuit breaker of this type had also been erected

to show the operating principles. Closing and opening demonstrations were also given of two air-blast circuit breakers—one rated at 132kV, 3500MVA, and the other for the new super-grid of 275kV, 7500MVA rating. In the high-voltage laboratory various aspects of testing and research were shown, including heavy-current heat tests, Schering bridge testing, protective gear testing, and X-ray examination of insulation. Finally, a demonstration was given of a wet 50 c/s power flash-over test of a 275kV outdoor current transformer using the 1000kV test transformer as well as an impulse flash-over on an insulator string from the 2250kV surge generator.

On Tuesday evening, a dinner-dance was held in the Great Hall of Durham Castle, which, it may be recalled, was founded by William the Conqueror in 1072 and is now occupied as University College of the University of Durham. Access to the Fellows Garden, during the evening, had been kindly granted by Lieut.-Colonel A. A. Macfarlane Grieve, Master of University College.

On Wednesday we visited the Billingham division of Imperial Chemical Industries, Ltd. The Billingham works occupies a site of about 1000 acres on the north bank of the River Tees, employs about 15,000 people, and is the largest chemical factory in the British Commonwealth. It has an annual aggregate output of more than 1,750,000 tons of chemical products, ranging from fertilisers to high-grade petrol. In a short tour of this factory it is possible to include only a small section of the whole. Our visit began in the boiler and power plants where we saw steam generated both for power generation and for process work. There are at present sixteen boilers, burning about 2000 tons of coal daily and producing about 900 tons of steam per hour, mainly at 800 lb per square inch. This steam generates about 65MW of electricity and pass-out steam at 275 lb per square inch is used in the factory for power drives to compressors, blowers and other heavy machinery. Low-pressure steam from these power units is then used for various chemical process work. Extensions to the boiler-house plant are in progress.

Our tour included a visit to the main machine shops where a great deal of the specialised engineering components, including pipe fittings, flanges, &c., for the chemical plants, are produced. We also saw the hydrogen plant, i.p. and h.p. compression plants, and ammonia synthesis plants. To complete this rapid view of fertiliser manufacture we saw the sulphate reaction and crystallisation plants, the packing shed and the No. 6 silo.

At this time of the year the silo is almost empty and advantage is taken of this condition to carry out maintenance on the conveyor machinery and to inspect the reinforced concrete shell of the silo for any signs of corrosion of the steel reinforcement.

On Thursday morning we made a short tour of Dunston "B" power station. This famous station, which was first commissioned in 1933, has been described in these columns and for the present we need do no more than recall that, although the original plant is more than twenty years old, Dunston "B" has always held a very high place among this country's steam stations, both from the standpoint of efficiency and coal consumption. This record is, no doubt, associated with the fact that Dunston "B" pioneered the adoption, in major British stations, of unit boilers with the reheat steam cycle.

Two power stations which are at present under construction were visited on Thursday afternoon. They are known as Stella North and Stella South and they are sited on opposite sides of the Tyne, about 3 miles up-river from Dunston power station. The sites of these stations are, perhaps, of more than local interest. For Stella North is being built on Newburn Haugh, which was the scene of a battle between the Scots and the English in 1640. The site of Stella South is renowned for less warlike associations, for it is there that Blaydon Races, famed in song, were run.

The work at Stella South being more advanced, it was that station which occupied most of our time during our short visit. Stella South will eventually house five 60MW hydrogen-cooled Parsons turbo-alternators, each taking steam, on the unit system, from a pulverised fuel-fired Clarke Chapman suspended-type boiler with a steaming capacity of 550,000 lb per hour, the stop valve steam conditions being 900 lb per square inch at 900 deg. Fah. Sturtevant electrostatic dust precipitators will be installed.

Coal will be delivered by rail, discharging by wagon tipplers and either being fed by conveyors direct to the boiler-house bunkers or being distributed by a bridge transporter over the rectangular coal store area which lies to the south of the station and has a capacity of 93,000 tons. Ash will be sluiced from the boilers and pumped to four ash ponds below ground level and adjoining the river, whence it will be loaded by telpher grab into diesel-driven barges for disposal at sea.

The power station building is brick-clad and of welded steel frame construction, the main members being jointed by fitted bolts. The foundations are of cellular-raft reinforced concrete construction, the upper deck being generally 1ft deep, but thickened to 3ft below the pulverising mills, while the base is 3ft thick and the headroom in the cellular spaces is generally about 9ft. These spaces carry auxiliary services such as steam pipework and cables. The whole area of the foundation raft is surrounded by sheet steel piling. There will be two brick-built chimneys, each 375ft high.

Stella North will eventually house four 60MW sets, each supplied from a 550,000 lb per hour boiler, the design of the plant being the same as that of Stella South.

The main differences are that the foundations for the North station rest on precast concrete piles and that, because of river water limitations, the cooling water will be circulated through four cooling towers on the North bank. In both stations the first plant is expected to be commissioned in 1955 and the installations are due for completion in 1957.

Both stations will be connected to the 132kV grid through 132kV switching stations equipped with Reyrolle air-blast switchgear. Subsequently, connection will be made through an adjacent 275kV switching station at Stella West to the 275 super grid.

The consulting engineers for both stations are Messrs. Merz and McLellan, and the civil engineering contractor is Sir Robert McAlpine and Sons, (Newcastle upon Tyne), Ltd. The steel frames for the turbine house, boiler house and stores are being built by the Cleveland Bridge and Engineering Company, Ltd. The steelwork for Stella South is already well advanced.

The Summer Meeting ended with a dinner-dance on Thursday evening at the Old Assembly Rooms, Newcastle upon Tyne, where the visitors were received by the president of the Institution of Electrical Engineers, Colonel B. H. Leeson, and the chairman of the North-Eastern Centre, Mr. H. Leyburn, and their ladies.

Short Notices

Technology of Engineering Materials. By B. Richard Hilton. London: Butterworth Scientific Publications, Bell Yard, Temple Bar, W.C.2. Price 36s.—A comprehensive knowledge of the materials he uses is essential to an engineer and the object of this book is to provide this knowledge in a concise way. Its contents are based upon detailed study of the standards and requirements of examination and technical course syllabuses in which the subject appears or predominates. The author has followed the logical sequence in dealing with the subject from pattern making and foundry work to the preparation, production and treatment of ferrous and non-ferrous metals and alloys. Following the first section on pattern making and moulding is a chapter dealing at length with ores and the production of iron in its various forms, smelting, melting, refining, &c. The next chapter on the mechanical treatment of steel covers the various operations such as rolling, surface protection, finishes, wire and tube making, forging, cold working, &c. The methods of heat-treating ferrous metals and alloys are then covered. In dealing with the production of non-ferrous metals and alloys notes are given on copper, nickel, aluminium and magnesium and many of the alloys produced from each. This section is followed by chapters on the mechanical- and heat-treatment of the non-ferrous metals and alloys. Each section of the book is well illustrated with photographs, drawings and diagrams, and a useful glossary is included. To assist the student reader each chapter concludes with some typical exercises on its subject matter. The book covers a very wide field and the matter has of necessity been considerably condensed in many cases; nevertheless, it provides a comprehensive work of reference which both the student and the practising engineer will find useful in his library.

Reviews of Research on Arid Zone Hydrology. U.N.E.S.C.O. London: H.M. Stationery Office. Price 25s.—This 212-page book has been published by U.N.E.S.C.O. in connection with its concerted attack which it has been carrying out on an international scale, on the major problems of the arid zones of the world.

The reports, each of them covering one of eight arid regions, were commissioned by U.N.E.S.C.O. in 1950 and are published as a contribution of value to workers in the field of hydrology in the arid zones, especially as they pertain to underground water and fluid mechanics. They review the research in North-West Africa, North-East Africa, the Union of South Africa and Angola, the Middle East, India and Pakistan, the United States and Canada, Latin America and Australia. Each report is followed by a bibliography. There is also a survey of world distribution of arid and semi-arid homoclimates, and a number of large homoclimatic maps with notes and suggestions concerning their use.

Books Received

Aircraft Propulsion, Theory and Performance. By A. W. Morley. London: Longmans, Green and Co., Ltd., 6 and 7, Clifford Street, W.1. Price 28s.

Advanced Mechanics of Materials. By Fred B. Seely and James O. Smith. Second edition. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 68s.

The Induction Motor. By Herbert Vickers. Second edition. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 70s.

Locomotive and Train Working in the Latter Part of the Nineteenth Century, Volume IV. By E. L. Ahrons. Cambridge: W. Heffer and Sons, Ltd., Price 15s.

Oxidation of Metals and Alloys. By O. Kubaschewski and B. E. Hopkins. London: Butterworths Scientific Publications, Ltd., Bell Yard, Temple Bar, W.C.2. Price 35s.

Elements of Propeller and Helicopter Aerodynamics. By Daniel O. Dommasch. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 35s.

Practical Stereoscopic Photography. By J. Moir Dalzell. Second edition. Revised by E. F. Linssen. Surrey: Technical Press, Ltd., Gloucester Road, Kingston Hill. Price 18s. 6d.

The British Instrument Industries Exhibition

No. II—(*Continued from page* 21, *July 3rd*)

BELOW we continue our account of some of the exhibits at the British Instrument Industries Exhibition at Olympia, London. The exhibition closes tomorrow, July 11th.

Electro-Methods, Ltd.

A pneumatic time-delay relay recently developed by Electro-Methods, Ltd., Caxton Way, Stevenage, Herts, is designed for a variety of applications in process control, valve sequence timing, controlling accelerating-contactors of motor starters, &c. It is a single-pole change-over switch in which make and break timing can be set to operate over the range of $\frac{1}{2}$ to 180 seconds. It comprises a compact pneumatic system and a substantial solenoid mounted in a cast aluminium case. The instrument, with the front cover removed, is illustrated in Fig. 7 on this page.

The pneumatic system, which is actuated by the solenoid, consists of a spring loaded bellows of synthetic rubber and an adjustable air valve. The solenoid is a rigidly constructed assembly

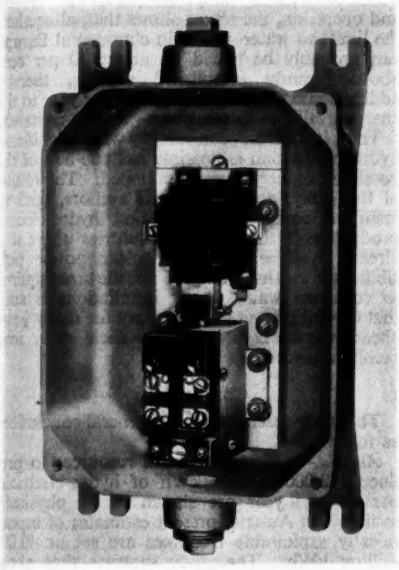

Fig. 7—Time Delay Relay—Electro-Methods

of low-loss silicon-iron laminations, with a fully impregnated coil and shaded-pole plunger. The shading ring is accurately positioned and it ensures a high sealing pull and silent operation. Coils are available for standard voltages, 50–60 cycles, and are designed to operate at voltages 10 per cent above or below nominal figures. The switch is fitted with spring loaded contacts of fine silver, the contact rating for a.c. being 5A at 230V or 3A at 440V, whilst for d.c. it is 1A at 110V (non-inductive) or 0·25A at 230V (non-inductive).

In the operation of the relay when the solenoid is de-energised the solenoid-plunger is withdrawn from the coil by a spring and simultaneously the bellows is compressed. Upon the solenoid being energised its plunger is pulled back into the coil permitting the bellows to expand under its own spring tension. The length of time the bellows takes to expand is determined by the setting of the air admission valve. At the conclusion of the expansion cycle the switch is automatically engaged and held until such time as the solenoid is de-energised. When the solenoid is de-energised the switch contacts snap over and the solenoid plunger is withdrawn from the coil to recompress the bellows.

The examples of the firm's temperature and humidity control equipment exhibited includes glass contact thermometers for close control to within 0·01 deg. Cent., and a range of precision cartridge thermostats of compact design incorporating a new suspension strut system which provides close control unaffected by vibration.

The cartridge thermostat consists essentially of two silver contacts mounted on, but insulated from, two steel members of low expansion coefficient. This element assembly is mounted, under tension or compression, in a seamless drawn brass or stainless steel shell. Changes in temperature cause the shell to contract or expand in length and, in consequence, subject the steel members to less or more tension or compression, thereby causing the contacts to make or break. To calibrate the thermostat at a specific temperature, a temperature adjusting screw is turned until the contacts open or close.

Leeds Meter Company, Ltd.

A combination meter, which provides a wide measuring range and is suitable for measuring widely fluctuating flows, is exhibited upon the stand of the Leeds Meter Company, Ltd., Armley, Leeds. The arrangement of this meter can be seen in the sectionalised photograph reproduced in Fig. 8. It consists essentially of a large bulk supply meter arranged in the main with a small motor on a by-pass below. The flow is controlled by an automatic flap valve which is operated by the differential pressure loss on each side.

When the flow of liquid is below a certain level the valve is closed and a load is applied on it by the heavy ball moving to the right-hand side of the cradle arranged on top of the valve bracket. The liquid passes through the by-pass where it is metered before passing to the main on the other side of the valve. As the flow of water increases the differential pressure builds up until the valve is fully opened, as shown in the photograph, at the same time the pressure of liquid closes the by-pass. The flow is then measured by the meter in the main line.

With this form of construction it is claimed that accurate readings are made throughout the range of the meter and inaccuracies are eliminated around the point of change over between the main and by-pass meters. The main and by-pass meters in the construction illustrated register on separate dials, but the firm makes similar units in which the readings are shown on a single dial to facilitate the taking of readings by a recording instrument.

For use where flows are very low compared with the size of the main the firm has developed a rotary meter unit for insertion in its "Helix" meter bodies. This arrangement is intended for use in the detection of waste water where the flow is very small and known to be less than would accurately be registered by a meter fitted for the measurement of normal flows. The arrangement is particularly suited for new schemes where there are small flows initially and it is known they will increase as a scheme progresses in stages. With these units a standard meter body for large flow measurement can be fitted in a main and fitted with a small flow metering unit. As the flow increases in steps as a project grows larger capacity units can be fitted until the final stage of the project, when, without disconnecting the main to fit a new body, the full capacity meter can be quickly and easily installed.

Baird and Tatlock, Ltd.

The equipment on the stand of Baird and Tatlock (London), Ltd., Freshwater Road, Chadwell Heath, Essex, includes an instrument combination of particular interest to process industries. This equipment consists of an "Electronik" potentiometer used in combination with one of the firm's type "B" absorptiometers for continuous measurement of small changes in colour density or turbidity of liquids flowing in chemical processes. A particular advantage of the arrangement is that it gives continuous null-balance measurement. It can be used to provide pneumatic or electric control of the process involved and installed as part of the control plant.

The absorptiometer comprises two identical vacuum emission photocells which are illuminated by a beam of light from a projector lamp through an optical system, one element of which is the mirror of a moving-coil galvanometer. Interposed between the galvanometer mirror and the photocells are two "continuous-flow" absorption cells on a sliding cell carrier. The cells are made of optical glass and have been specially designed for continuous flow. The liquid under examination flows through one cell and a liquid used as a reference standard through the other.

Any change in the amount of light falling on one photocell, due to variation in absorption in the liquid under test, causes an out-of-balance e.m.f. from the photocell circuit to be applied to the specially adapted amplifier and input system of the potentiometer. The potentiometer circuit of this instrument is used to energise the coil of the reflecting galvanometer. When an out-of-balance signal is detected by the amplifier the instrument balancing motor drives

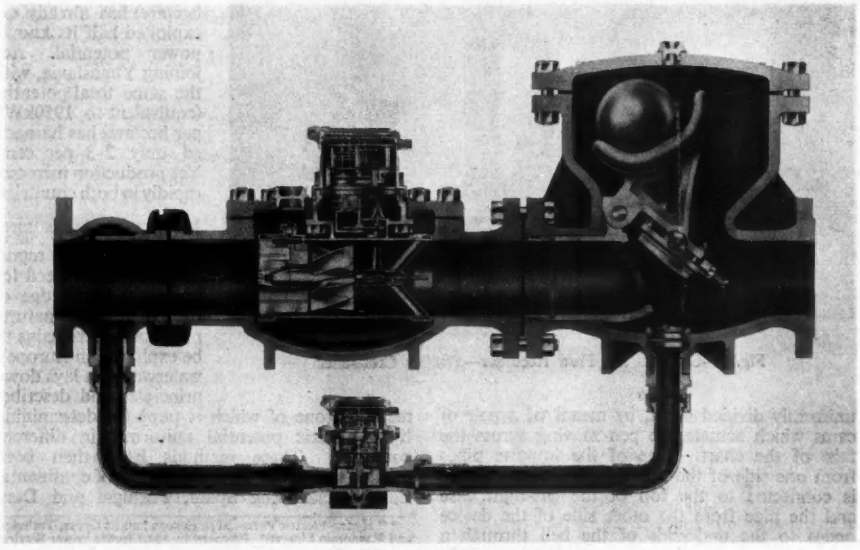

Fig. 8—Combination Meter—Leeds Meter Co.

the slide wire of the potentiometer in such a direction as to deflect the galvanometer to increase or decrease the area of illumination on the affected photocell until the amount of light falling on this photocell becomes equal to that on the standard photocell. Thus the photocells are kept equally illuminated, thereby automatically compensating for changes in lamp intensity due to normal mains voltage fluctuation.

The h.t. voltage for the photocells is derived from the amplifier in the potentiometer and is stabilised by neon tubes. The high input impedance required to match that of the photocells is obtained by the use of a simple cathode follower preamplifier. To counter long-term changes which may occur in the photocell characteristics or in the preamplifier stage an automatic "rezeroing" device is incorporated. With the light on the photocells extinguished and "dark current" only flowing, on closing a switch the instrument automatically adjusts a voltage dividing network so that under these conditions the voltage fed into the amplifier is zero. It is not anticipated that this operation will need to be carried out more often than once every twenty-four hours and it can, if necessary, be made fully automatic. A sensitivity adjustment makes available the full deflection of the instrument for a wide range of percentage absorption.

The potentiometer may be in either circular or strip chart form, and incorporates various means for signalling, control action, &c. The absorptiometer can be supplied with colour filters and absorption cells to suit specific liquids.

Walker Crosweller and Co., Ltd.

A new instrument exhibited by Walker Crosweller and Co., Ltd., of Cheltenham, Glos, is the "Arkon" model "1601" gas and air flow recorder to be seen in the sectional photograph Fig. 9. This instrument is designed to work in conjunction with a differential pressure device—usually an orifice plate—installed in the gas stream. In it the rate of flow is proportional to the square root of pressure head across the orifice plate, and it is measured by the movement of a liquid sealed bell in a gas-tight case in the body of the instrument.

Movement of the bell is translated into linear movement, so that it can be recorded on a uniformly divided chart, by means of a pair of cams which actuate the pen moving across the face of the chart. One of the impulse pipes from one side of the differential pressure device is connected to the top of the gas-tight case and the pipe from the other side of the device opens to the underside of the bell through a standpipe. A control spring at the side of the case is connected to the top of the bell through arms and a shaft which rotates on ball bearings and passes through a gland seal in the top of the case. This connecting shaft is keyed to one of the cams.

Variations in gas flow create a change in differential pressure which causes the bell to move up or down until equilibrium is restored by a change in spring tension. The connecting arm cam actuates the second cam, which is keyed to the pen shaft and is maintained in contact with the actuating arm by means of a counterweight.

A double piston valve operated from inside the instrument case ensures simultaneous shutting off and equalising for zero testing purposes. The 6in high chart of the recorder can be driven by a.c. mains or a clockwork motor, and has a visible width covering sixteen hours' operation.

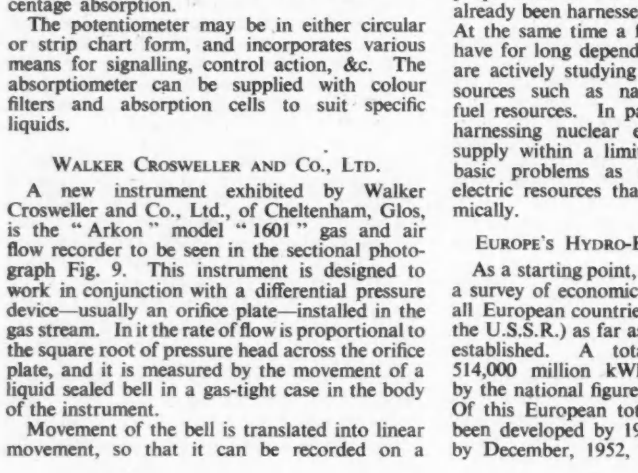

Fig. 9—Gas and Air Flow Recorder—Walker Crosweller

(To be continued)

The Water Power Resources of Europe

The Secretariat of the United Nations Economic Commission for Europe (E.C.E.) published in Geneva recently the results of an international survey of water power resources covering a large part of Europe. A major conclusion of the report which is reviewed here is that, due to modern developments in construction and plant, recent estimates of Europe's hydro-electric potentialities can be raised by one-fifth.

In all countries hydro-electric production is increasing rapidly each year, and considerable proportions of the more favourable sites have already been harnessed in a number of countries. At the same time a few of the countries which have for long depended mainly on water power are actively studying possibilities of alternative sources such as natural gas and low-grade fuel resources. In particular, the prospects for harnessing nuclear energy for electric power supply within a limited number of years pose basic problems as to the remaining hydro-electric resources that can be exploited economically.

Europe's Hydro-Electric Potentialities

As a starting point, the E.C.E.* report presents a survey of economic limits to water power in all European countries (apart from Iceland and the U.S.S.R.) as far as they have been nationally established. A total yearly production of 514,000 million kWh is at present accepted by the national figures as economically possible. Of this European total about 22 per cent had been developed by 1950 and about 26 per cent by December, 1952, the study reports. However, the availability of hydro resources and the percentage already harnessed both vary widely among individual European countries. The study shows that among those countries which depend on water power for their supply of electricity, Italy, for example, with 50,000 million kWh (1660kWh per hectare) has already exploited half its known power potential. Adjoining Yugoslavia, with the same total potential (equivalent to 1950kWh per hectare) has harnessed only 2–3 per cent. Yet production increases rapidly in both countries.

Methods of Measuring

The E.C.E. report emphasises the need for improved knowledge of the extent of the natural power which remains to be exploited in Europe's waterways. It lays down principles and describes methods (one of which is new) for determining hydro-electric potential uniformly in different countries. These methods have then been applied throughout the major part of continental Europe, excluding Spain, Portugal and Denmark but extending eastward as far as eastern Poland and western Roumania. From an examination of all available evidence it is shown that both the "technical" and "economic" levels of exploitability tend to vary consistently with the gross strength of water flow and head.

Considering new conceptions and new standards of efficiency in power plant construction and operation, the report shows that, altogether, the limits to water power in continental Europe can probably be raised by about 20 per cent above recently established ceilings, thereby adding some 50,000 million kWh per year to the energy available to meet ever-growing demands.

Thus, in no European country where significant hydro production is possible has one-half of the possible output yet been developed. The results of the study, according to its authors, tend to justify a continued reliance on hydro-electric production in the future in countries where it is already well established, nuclear power possibilities notwithstanding. Since the time required to construct water power installations is such that careful planning is necessary for many years ahead, the authors hope that their study may facilitate investment planning.

Conclusions

The study reaches tentative general conclusions as follows :—

Austria.—Although natural resources to produce 152,000 million kWh of hydro-electricity per average year are shown to be physically available in Austria, present estimates of economically exploitable resources are set at 40,000 million kWh. The study suggests that about 60,000 million kWh might be technically exploitable and that there is probably scope for an increase in Austria's "economic potential" above the highest estimates yet published.

Czechoslovakia.—Of the 39,000 million kWh per year shown to exist only about 18 per cent is considered economically usable, and this practical limit appears unlikely to be greatly exceeded.

France.—Gross possibilities total 255,000 million kWh yearly: 60,000 million (60 milliard) kWh are considered economically exploitable and a further limited increase in this total potential may become possible in the future.

Eastern and Western Zones of Germany.—An annual output of about 111,000 million kWh exists. Some 18,000 million kWh would be likely to represent the economic total and of this one-half has already been developed.

Italy.—Italy also has developed a high proportion of her known hydro-electric potential. It is shown, however, that at least 330,000 million kWh is physically present and it is considered likely that existing estimates of production economically possible in the future can be raised substantially as need arises.

Poland.—About 32,000 million kWh theoretically exists. The study estimates that 5500 million kWh might be produced economically in an average year, a total somewhat higher than might be expected from the nature of the terrain.

Switzerland.—The study estimates that 56,000

* "Hydro-Electric Potential in Europe and its Gross, Technical and Economic Limits." Prepared by the Electric Power Section, Industry Division, U.N. Economic Commission for Europe, Geneva. Available in English from Sales Section, European Office of the United Nations, Geneva, Switzerland. Price 7s. 6d.

million kWh of Swiss hydro production might be technically usable ; this is more than twice the official economic total. Further potentialities may therefore prove economic in this country which depends so largely on water power.

Yugoslavia.—Important possibilities for power production, amounting to nearly 49,000 million kWh yearly, remain unused in Yugoslavia. The study shows that this total exploitability is, however, unlikely to be further increased despite the incompleteness of existing surveys.

Method of Analysis

Various long-term tendencies in assessment and development of Europe's water power are analysed in the report. In most countries estimated resources for hydro production have been subject to successive upward revisions during the last thirty to forty years which have completely changed the conception of what resources exist.

The report points out that the range of possibilities for which a definition of water power potential must allow " has been immensely broadened of late," because of developments such as the following : (*a*) integration of projects, including large-scale diversions of water to concentrate head ; (*b*) use of multi-purpose projects combining power generation with other uses of water ; (*c*) possibilities for development of very low heads ; (*d*) possibilities for fully developing marginal water power by means of self-operating stations ; (*e*) developments in pumping plant and towards possible new sources of pumping energy—i.e. pumping both to improve river regulation and to create utilisable head ; (*f*) possibilities of development in artificial precipitation as a means of concentrating or supplementing run-off.

Economic Limits

The report finds, however, some evidence that the possibilities for large-scale design of projects are approaching limits defined by operating efficiency and specific weight and cost rather than by practical limits on construction. It should not, therefore, be concluded that technical progress " can continue to compensate for the natural disadvantages of the sites which must gradually be harnessed in order to meet an ever-growing yearly increment in demand." Nevertheless, from present estimates it appears unlikely that costs per kWh from plants running on nuclear heat will be low enough to render hydro installations obsolete.

Information on Precipitation and Stream Flow

Finally, the report points out that much of the uncertainty as to the future supply of water power rests on the inadequacy of hydrological and meteorological records and measurements. Some European countries still lack comprehensive surveys of water resources and it is a frequent complaint of construction engineers in all parts of the world that availability of hydrologic records is the most important element in the planning of hydro-electric projects. The report points out that one strong reason for a consistent approach to the assessment of water resources lies in its value in less developed countries—many of them outside Europe—where an opportunity exists to profit from a long European history of hydro development.

The principle on which the survey described in the E.C.E. report has been made is that the natural physical potentiality, as given by mean flow in the river basins, should be established to furnish a fixed upper limit of " gross hydro-electric potential," which may be compared in all countries. Output from installations technically feasible at a given time can then be determined uniformly and at regular intervals according to methods which allow the results to be compared with the gross potential water flow.

The report thus lays down first the technical procedure for establishing gross hydro-electric potential as a fixed upper limit to the water power that physically exists. Next it establishes the relationship between this gross potential and the resources technically and economically realisable. It is believed that in this way the planning of investment for large-scale hydro-electric schemes can be related to some general horizons fairly clearly defined.

Scientific Research in U.S.A.

A review of scientific research in U.S.A., prepared by the British Commonwealth Scientific Office, was published last week. The B.C.S.O. in Washington is maintained to facilitate the exchange of scientific and technical information between the United States Government and the British Commonwealth. It prepares an annual review of scientific activity in the U.S.A. but the present one is the first to be published.

Commenting on the growth of research in the United States, the report notes that expenditure on research and development has grown rapidly during the past ten years, most of the increase being devoted to military projects. The amount spent increased by 270 per cent during the past decade and it is estimated that 2930 million dollars will be spent on these activities during 1952/53. More than half of this sum will be provided by the Government. The Federal Government itself employs directly some 91,000 science and technology graduates, more than half of them being engineers. Of the total some 58,000 are employed on research projects. The figures do not include scientists working in factories and laboratories operated for the Government by outside bodies such as the Atomic Energy Commission, private firms and universities.

Research in Universities is expected to cost 350 million dollars during the year 1952/53, and more than 80 per cent of this sum will be provided by the Federal Government in the form of grants or contracts. Nine-tenths of the total expenditure will be on research in the biological and physical sciences, including engineering, and one-tenth on the humanities and the social sciences. Educational authorities anxious to preserve a balance between the arts and the sciences in university post-graduate schools are reported to be worried by the heavy bias of university research in favour of science and technology. They fear that one result may be a dearth, in ten years' time, of faculty members in the humanities and social science.

The distribution of the large sums available for the sciences also presents problems. The greater part of these will be used for the investigation of problems of applied science. Thus, it is feared that there may be a lack of balance between the efforts devoted to applied science and to pure science, which is the primary business of the university. The report expresses grave concern that the output of graduates in science, and particularly in engineering, may not be sufficient to meet the needs of industry. Industry demands more and more graduate engineers, but authoritative engineering bodies suggest that this demand could be largely met by preventing the drain of engineers to non-professional work and by increasing the effectiveness of the engineers already in industry. It is estimated that there are nearly 50,000 research workers engaged in engineering projects in American universities. This figure includes faculty members, full-time research workers, post-graduate workers and junior staff. Half of the work being carried out is for the military services.

Industrial Research.—Industrial research and development gives employment to about 71,000 persons with university degrees or equivalent qualifications. In addition there are some 95,000 technical and non-technical assistants employed. There are about 2800 industrial laboratories, more than half of which have less than ten professional staff. Seven laboratories have staffs of more than 1000 professional workers. Research budgets in industry in normal times (there is an increase under war-time conditions) tend to remain constant at between 6 and 8 per cent of the capital investment on new plant and equipment.

Conservation of Materials.—The problem of shortages of raw materials is receiving considerable attention in the United States, the report continues. It is forecast that by 1975 the U.S. demand for minerals will have risen by about 90 per cent and for agricultural products by about 40 per cent. It is not expected that mineral resources will become exhausted but that the cost of winning them will become prohibitive. The Materials Policy Commission points out that the U.S., formerly one of the world's biggest suppliers of raw materials, already imports more than she exports.

In connection with atomic energy and nuclear physics, the report states that expansion of the programme for producing fissionable material will cost 4200 million dollars over the next five years : 1000 million dollars of this will be used to provide a gaseous diffusion plant for the production of U235 in addition to the 500 million dollars plant at Paducah, Kentucky. A further 125 million dollars is to be spent in extending the Tennessee Valley Authority power plants. These figures are large but they should be compared with the vast Defence Department budget which accounts in one year for 46,000 million dollars, especially since the U.S. has repeatedly stressed the great importance it places on atomic weapons.

It is estimated that the United States will consume in 1975 double the energy which was used in 1950. This increase will continue a trend that has existed since the commencement of the century. Taking an index of 100 for the energy used in 1900, the consumption in 1950 was 445. On the same basis production had reached a figure of 472 by 1950. It is pointed out in the report that the sources of energy have changed notably in the past fifty years. To-day coal provides less than half the energy requirements of the country. In 1900 it supplied 90 per cent, the fall being due to the rapid expansion in the use of oil. There is little pessimism at present about an immediate shortage of oil, for the discovery of new supplies has more than kept pace with increasing consumption. It has been estimated that the first commercial oil-from-shale plant may be brought into operation by 1960. Work on fuel technology in the U.S. includes investigation of the Fischer Tropsch process and other processes for getting oil from coal, the construction of a coal hydrogenation plant for the production of aromatic hydrocarbons, and experiments in underground gasification.

Amongst other items in the report it is noted that water is used at the rate of over 200 gallons a day per person in some parts of the United States. In addition the increase in industrialisation and in industrial demands has made water conservation an important study. An important development is the perfection of methods of purifying sea water and other brackish waters to give water suitable for consumption and for use in industry. It is claimed that, by using a recently developed " permionic membrane," up to two-thirds by volume of potable water can be produced from brackish water. The process is said to be economical but a supply of cheap electricity (costing no more than 0·3 cents per kWh) is essential if the cost is to compare with that of present methods of purifying river water. Some recent developments described include a new building brick and a method by which concrete slabs for upper floors or flat roofs can be cast at ground level and jacked into position.

Technical Reports

Detection of Incipient Failure of Insulation by Observations of Non-Linearity (Ref. V/T108). By G. Mole, Ph.D., F.Inst.P. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 24s., postage 4d.—This report describes a method for detecting non-linearity between current and voltage, which indicates the presence of moisture and possibly also other types of defect. Equipment employing this method has been developed in experimental form and tests carried out in the laboratory at voltages from 100V to 20kV (r.m.s.). The results support an explanation based on restriction of the motion of ions by microscopic internal barriers.

An Examination of Four Self-supporting Insulating Films (Ref. A/T137). The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 10s. 6d., postage 3d.—Films of cellulose triacetate, cellulose acetate butyrate, polythene and polyvinyl chloride have been examined with a view to specifying methods of test for such materials, and to provide data so that their suitability for any specific application may be the more readily assessed.

Properties of Automobile Suspension Springs*

By C. J. DADSWELL, Ph.D., B.Sc. (Eng.),† J. E. RUSSELL, M.A.,‡ and R. FIELDING§

In the full paper there is given a description of the manufacture of laminated, coil and torsion bar springs, together with some notes on the various defects which may arise and the precautions taken to prevent them occurring. The mechanical properties of springs are discussed, and tentative design data are presented. Consideration is given to shot peening and scragging, and an analysis is presented of the internal stresses caused by these processes.

Properties of Springs

Material.—It has already been stated that all motor-car springs manufactured in Great Britain are of silico-manganese steel. The reason for this is one of those queer combinations of metallurgy and economics which serves to keep in use a material which has many disadvantages.

As pointed out by Platt (1948),|| automobile springs are more highly stressed than most other types of springs, since the weight of a spring being inversely proportional to the square of the permissible maximum stress, requires a high stress to allow a saving of weight and consequent reduction of cost.

Now the actual choice of a material to satisfy these more arduous working conditions is governed mainly by considerations of the "static" mechanical properties and of the fatigue properties of the material. The former govern the possibility of the spring "settling," that is, taking a permanent set; the latter govern the possibility of fracture in service. Although an increase of hardness generally implies an increase of limit of proportionality (in tension or torsion) and thus less possibility of settling in service, the fatigue properties do not improve

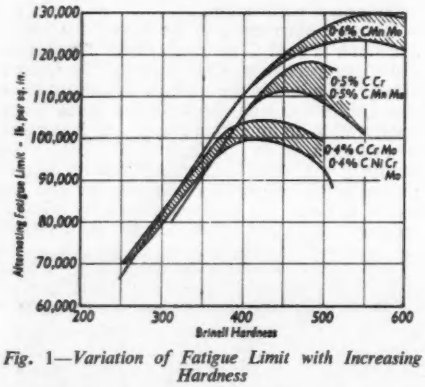

Fig. 1—Variation of Fatigue Limit with Increasing Hardness

proportionately at these high hardness levels. Fig. 1, taken from Garwood, Zurburg, and Erickson (1951) shows how various steels behave in regard to endurance limit as the hardness rises. Silico-manganese steel probably falls near the centre group of steels, and 95 tons per square inch tensile, or 430 Brinell, probably represents the optimum hardness so far as fatigue resistance is concerned.

Now, generally speaking, carbon steels would not be adequate for the high load-capacity expected of automobile springs; for, in order to obtain a sufficiently high hardness to minimise the possibility of settling a very low tempering temperature would have to be used which would not be high enough to relieve stresses set up in quenching, and the fatigue properties would be poor. Moreover, even at the optimum tempering temperature, the limit of proportionality of a carbon steel is lower than that obtainable from an alloy steel. Table I shows typical figures for various steels.

Although of the three alloy steels mentioned in Table I the silicon-manganese steel and the chrome-vanadium steel have similar properties after tempering, and are distinctly better than the typical nickel-chrome-molybdenum steel cited, this does not imply that there are not other alloy steels which would have properties much better than silicon-manganese or chrome-vanadium for highly stressed springs. Indeed, certain steels of the carbon-molybdenum and low-alloy nickel-chrome-molybdenum types are being investigated at the present time. However, a consideration which, to the buyer of springs, is of equal if not greater importance than metallurgical ones, is that of cost. Since silico-manganese is much cheaper than any other alloy steel, and car designers are willing to limit their needs for highly stressed springs to the properties which can be obtained from silico-manganese, it is hardly surprising that this is the predominant spring steel in Great Britain to-day. Chromium-vanadium steel is still very much used in the United States of America and it possesses certain advantages over silico-manganese steel from a manufacturing point of view, but during the last war its use was officially discouraged in England on grounds of economy, and it has never recovered from this set-back.

Silico-manganese steel is thus used almost exclusively for automobile springs, not because of any inherent metallurgical advantages, but because it possesses, at the moment, the most favourable balance between strength and cheapness. On the other hand, it is a nuisance in manufacture because it is prone to many defects to which chromium-vanadium and other spring steels are not subject.

"Static" Properties of Silico-Manganese Steel.—For the information of users this account of the properties of silico-manganese steel under tensional and torsional tests is given.

All steel for automobile springs is heat-treated by oil-hardening and tempering. The approach to the oil-quench varies with different spring makers. Thus, for coil springs, the spring may be quenched "off the mandrel," that is, quenched in oil while still hot after the coiling operation, or allowed to cool before being reheated to the quenching temperature. The latter process obviously gives a greater degree of control over the operation, that is, the exact quenching temperature, uniformity of heating, refining of microstructure before hardening, and so on, but the evidence of fatigue and service data is

Table I

Steel	Approximate composition							Hardened in	L.P. in torsion shear stress, tons per square inch when tempered at			
	C	Si	Mn	Ni	Cr	Mo	V		300 deg. Cent.	400 deg. Cent.	450 deg. Cent.	500 deg. Cent.
0·6 per cent carbon ...	0·6	0·2	0·8	—	—	—	—	Oil	—	42	42	37
Silico-manganese ...	0·55	1·8	0·8	—	—	—	—	Oil	—	—	53	48
Chrome-vanadium ...	0·5	0·3	0·65	—	1·0	—	0·23	Oil	—	58	53	49
Nickel-chrome-molybdenum (En.26)	0·45	0·20	0·6	2·5	0·6	0·65	—	Oil	31	50	47	44

Table II—*Tensile Tests on Silico-Manganese Bar of Various Diameters*

Cast No.	Analysis		
	C	Si	Mn
O.C. 2691	0·57	1·98	0·97
O.C. 3789	0·59	1·97	1·00
O.C. 3509	0·63	1·80	0·85

Bars heat-treated: 900 deg. Cent. oil quench, 470 deg. Cent. temper, cool in air.
All stresses quoted in tons per square inch.

Cast No.	Bar diameter as treated, inches	L.P.	Proof stress				Ultimate stress	Elongation, $4\sqrt{A}$	R.A., per cent
			0·05 per cent	0·1 per cent	0·2 per cent	0·5 per cent			
O.C. 2691	¼	74	87·4	89·0	91·4*	—	—	—	—
	⅝	85	88·3	89·5	91·0	93·5	99·3	8·8	14·1
	1½	77	83·8	85·8	87·8	90·0	97·5	4·8	7·4
O.C. 3789	¼	78	85·8	86·9	88·2	90·8	98·4	13·7	29·0
	⅝	83	85·9	86·8	88·1	90·0	97·6	12·6	28·7
	1½	71	79·9	82·7	84·8	87·8	96·3	11·6	23·0
O.C. 3509	¼	81	86·6	88·0	89·9	92·0	96·6	4·4	9·0
	1½	79	83·7	86·0	88·5	91·5	98·7	5·2	7·5

* Specimen broke prematurely in the head.

Table III—*Torsion Tests on Silico-Manganese Steel at Different Hardness Levels*

Cast No.	Analysis		
	C	Si	Mn
32339	0·59	1·75	0·68

Material heat-treated as ⅝in diameter bars, oil quenched from 890 deg., and tempered at three different temperatures. Specimens ⅜in diameter by 2½in parallel.
All stresses quoted in tons per square inch (shear stress).

Tempering temperature	Hardness (Brinell)	L.P.	Stress to give stated degree of permanent shear strain (radians)									
			0·05 per cent		0·1 per cent		0·2 per cent		0·5 per cent		1 per cent	
			Nom.	True	Nom.	True	Nom.	True	Nom.	True	Nom.	True
450 deg. Cent.	458	39·2	49·4	42·1	53·0	44·4	57·9	47·6	63·6	51·8	67·5	53·5
490 deg. Cent.	427	36·9	46·8	40·0	49·5	41·6	52·8	43·5	57·6	46·4	61·3	48·1
540 deg. Cent.	387	34·9	42·9	36·3	45·1	37·6	48·4	39·3	52·7	42·0	54·6	42·1

Tensile results on the same material were as follows:—

Hardness	L.P.	Proof stresses				M.S.	El., per cent	R.A., per cent
		0·05 per cent	0·1 per cent	0·2 per cent	0·5 per cent			
458	69	80·7	84·9	89·1	94·0	101·2	9·2	26·7
427	67	76·3	78·6	81·0	84·0	90·5	10·8	27·1
387	60	67·9	70·5	73·3	75·8	82·8	13·2	31·9

Note.—The "nominal" stresses quoted in the torsional tests are those calculated from the applied torque on elastic theory only—that is, given by $16M/\pi d^3$. The "true" stresses were obtained by a geometrical construction equivalent to the familiar Upton-Nadai formula:

$$t_{true} = \tfrac{1}{4}[3t_{nom} + \gamma \cdot dt_{nom}/d\gamma],$$ where t and γ denote surface shear stress and strain respectively.

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§ Manager, spring department, English Steel Corporation, Ltd.
|| An alphabetical list of references is given below.

that, provided the quench off the mandrel is done with reasonable care, there is actually little to choose between the two methods. However, for the sake of uniformity, the following results are quoted after a standard heating for quenching. The quenching temperature is usually 900 deg. Cent., but this temperature is not very critical, since silico-manganese steel is not prone to heavy coarsening of structure on over-heating. The temperature could range between 880 deg. and 1000 deg. Cent. without producing much difference in the results. Tempering is usually done at about 480/510 deg. Cent. to give a hardness of 400/450 Brinell, although for special high-duty springs a lower temperature and higher hardness may be used.

The tensile test results shown in Table II have been obtained on bars of sizes varying from ½in diameter up to 1½in diameter on a works heat-treatment.

Some results on torsional tests are shown in Table III, and do not call for any special comment. The modulus of rigidity was found to be $11{\cdot}4\times10^6$ lb per square inch. This was, of course, obtained on the laboratory test pieces, of size $\frac{1}{16}$in diameter. However, it is rather curious to note that on production torsion bars, of diameters ¾in up to 2¼in, the modulus appears to be rather lower, being of the order of $10{\cdot}5$–11×10^6 lb per square inch, even after full corrections have been allowed for all possible sources of error. It would be interesting to know whether similar behaviour has been noted by other workers.

Fatigue Properties.—It is not easy to quote fatigue results on spring steels which would be applicable generally to all types of springs. In the first place, while practically every automobile manufacturer has generous facilities for the fatigue-testing of springs, and they all appear to be carrying out regular testing programmes, very few of their results have ever been published. Consequently, one is generally forced to rely on reports by research institutes and others, who are usually performing their fatigue tests in order to elucidate the effects of particular manufacturing variables, so that their tests are comparable within themselves but often not of general relevance.

Secondly, automobile spring designers are generally not interested in the fatigue limit as such, but in the life at loads which are known to be above the fatigue limit. Thus, generally speaking, the spring in a fatigue test is loaded up to "full bump," that is, the full deflection that the spring might take in service, usually limited by some mechanical stop. If a number of cycles to failure greater than 300,000 is obtained, the spring is usually satisfactory. Service failures are never caused by the large number of relatively small oscillations of the springs which normally occur on the roads; only the occasional large bump contributes towards spring failure, and 300,000 cycles of full bump will represent many thousands of miles of normal car usage. However, the use of "lives" for comparing fatigue resistance makes comparisons very difficult and dangerous, since even if the applied stress-ranges are rigidly comparable, a wide "scatter" of life is to be expected even on "identical" springs tested under "identical" conditions.

Thirdly, automobile springs are stressed through oscillations round a certain degree of deflection, the "static" deflection which would be caused by the weight of the car when stationary. Since almost every car spring has thus a different range of stressing, the lives obtained from one are not comparable with those obtained from another. Further, the fatigue properties under alternating stress, which are the ones most easily obtained in the laboratory, are not of direct relevance.

Fourthly, the bar size of the spring will exert a certain "mass-effect" on the fatigue results, and it does not follow that results obtained on springs of one size (even when all the stresses are converted to "true stresses" by the application of the various correction factors) are necessarily applicable to springs of another size.

In addition to the above factors which are external to the metallurgical conditions of the testing, there are such profound influences on the life as surface-finished, shot peening, and scragging. The position is thus seen to be very complex.

However, for the record, Table IV presents some average value of fatigue limits in alternating tension and torsion of silico-manganese steel, hardened and tempered to about 460 Brinell hardness, using polished specimens. The effect of various other influences will be considered in their turn.

TABLE IV

Fatigue limit in alternating torsion, based on 2,000,000 cycles = ±30 tons per square inch shear stress, approximately (C.S.J. No. 15 pg. 28, 29).	
Fatigue limit in alternating torsion, based on 200,000 cycles = ±32 tons per square inch shear stress, approximately (C.S.J. No. 15 pg. 28, 29).	
Fatigue limit in direct tension, based on 2,000,000 cycles = ±54 tons per square inch direct stress, approximately.	
Fatigue limit in direct tension, based on 200,000 cycles = ±56 tons per square inch direct stress, approximately.	

Decarburisation and Fatigue.—It is well known that the loss of carbon at the surface of a spring which may occur during the processes which require the spring material to be heated over about 900 deg. Cent. (for example, rolling, coiling and hardening) causes a great reduction in the fatigue limit of the steel. Thus, Hankins and Becker, in 1931, reported tests on rotating cantilever tests on silico-manganese hardened and tempered to 450/470 Brinell :—

Machined and polished with no decarburisation : F.L. = ±46 tons per square inch (direct stress).

Normal furnace treatment and polished : F.L. = ±27 tons per square inch (direct stress).

Heavily decarburised (0·005in decarburisation) and polished : F.L. = ±21 tons per square inch (direct stress).

Figures telling a similar story have been frequently reported since 1931, for example, Kenneford and Ellis (1950) reported that the introduction of 0·005in decarburised case on to a silico-manganese steel of 550 V.P.N. reduced the rotating cantilever fatigue limit from ±58·5 tons to ±32 tons per square inch.

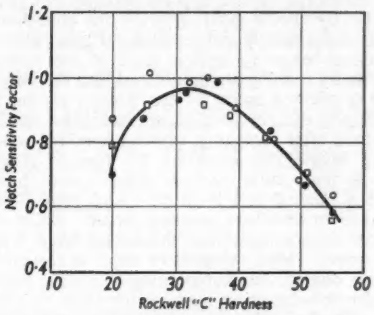
Effect of Mechanical Damage on Fatigue.—Any surface damage due to careless handling of springs during manufacture or service may cause a drastic reduction of fatigue properties, since, being generally very hard (430 Brinell upwards) their yield point is relatively high and the detrimental effects of the stress-raiser are not able to relieve themselves by plastic flow, such as occurs in softer steels.

It is interesting to note in passing that increasing hardness alone does not necessarily lead to increasing notch sensitivity in fatigue, although there is a widespread impression to this effect. Indeed, the notch sensitivity may actually fall with rising hardness, and Fig. 2 shows another curve from Garwood, Zurburg, and Erickson (1951) showing the notch-sensitivity factor i.e. :—

Actual drop of fatigue limit due to pressure of a notch ÷ expected drop of fatigue limit due to pressure of a notch, based on stress concentration factor as a function of hardness for steel S.A.E. 4063 (a manganese-molybdenum steel with carbon 0·6/0·67, manganese 0·75/1·0, and molybdenum 0·2/0·4 for bending-fatigue.

The greatest notch sensitivity occurs at 30–35 Rockwell (64–73 tons per square inch) and falls away for higher hardnesses. The authors do not possess a similar curve for silico-manganese steel, but they should evidently be wary in assuming that a high hardness necessarily implies high notch sensitivity. However, a saving grace is the fact that while one stress-raiser on a polished surface may be disastrous, the effect of covering the surface with stress-raisers, for example, by shot peening, or merely by the use of ground bar which has roughened uniformly in heat-treatment, is nothing like so troublesome, and the stress-raisers simply run into and more or less eliminate each other. However, the effect of one stress-raiser very much more acute than those which surround it may again be disastrous, for example, a roke or seam in a bar, or bad indent due to careless handling will almost certainly cause early failure.

Shot Peening of Springs.—The effect of shot peening is to cold-work the surface layer, and to set up a compressive stress in the surface. The early work on the effects of peening tended to show that the fatigue properties were very greatly enhanced after the treatment. However, later work has shown that when results obtained on very carefully prepared and polished specimens are compared with similar specimens shot peened, the rise in fatigue limit is seldom more than about 5 per cent and there may even be reductions of fatigue limit. This is particularly



Steel : S.A.E. 4063 (0·6/0·65 per cent carbon, manganese-molybdenum) ; hardened and tempered ; alternating bend fatigue tests ; specimen 0·3in diameter at bottom of notch.
0 notch radius : 0·035in.
0·020in.
0·015in.

Fig. 2—Variation of Notch-Sensitivity Factor with Increasing Hardness

true of the harder, higher carbon steels ; a greater improvement of properties is obtained on relatively soft steels and on steels of a high work-hardening capacity, such as austenitic steels. Typical examples of results on spring steels are shown in Table V.

TABLE V

Steel	Type of test	Fatigue limit	
		Polished, tons per sq in	Shot peened, tons per sq in
0·6 per cent carbon (H. and T.)	Rotary bend	±36	±37·8
0·45 per cent carbon (H. and T.)	Rotary bend	±36	±33·5
Silico - manganese (H. and T).	Rotary bend	±45·7	±44·0

However, if results on shot-peened springs are compared with those on unpeened, unpolished springs, there is, as one might expect, an enormous improvement in properties, and, if one is concerned with fatigue life at over-stress, the improvement may range from a few hundred per cent up to infinity, depending on the applied stress level. Thus, from a manufacturing point of view, the process is very valuable since it confers all the advantages of a very highly polished spring without having to go to the trouble of polishing.

It is possible in certain cases to eliminate the effects of slight stress-raisers by shot-peening, provided the stress-raiser is not too severe. Thus, Horger and Niefert (1944) give the following data on an 0·45 per cent carbon steel ; using rotary bending fatigue (Table VI).

TABLE VI

Surface condition	Rotary bending fatigue limit	
	Plain specimen	Specimen with ¼in radius fillet
Polished, not peened	±13·8	±11·6
Peened with 0·055in diameter shot	±15·2	±15·2

The results, incidentally, show the lifting of the fatigue limit by peening on a relatively soft steel.

The stresses set up in leaf springs after peening were investigated by Humphrey (1947), who measured the change in camber of the leaves after successive layers had been removed with dilute sulphuric acid. He found considerable variation of the amount of distribution of the stresses. The position of maximum stress varied from on the surface to about 0·007in below the surface, and the maximum amount varied from about 63 tons per square inch to about 37 tons per square inch. Unfortunately, no very detailed information on the peening conditions is given in Humphrey's paper.

It is the general rule to shot-peen springs

before scragging. The work of Almen (1917) in America showed that the fatigue results when the peening preceded scragging were much better than when the order was reversed. This result is probably due to the fact that plastic work applied in one direction will often cause relief of stresses set up through plastic work in another direction, a point brought out strikingly by Polakowski (1951) on cold-drawn bars subsequently cold-twisted. If the peening is done before scragging, some of the stresses set up by peening are diminished, but the fatigue life is affected more by the stresses caused by scragging than by peening, so that if the peening is done after scragging, and some of the scragging stresses are removed, the loss of fatigue life is much more marked. On the other hand, it has been shown by Straub and May (1949) that if torsion bars are shot peened while still under the scragging load the fatigue life is much improved. Hence there is no relief of scragging-stress due to the shot peening, since the bar is under the scragging load all the time. Consequently the residual stresses after loading are higher than in either of the other two procedures and the fatigue life is correspondingly improved.

Finally, it should be mentioned that it is possible to over-peen springs, for example, to use too high an intensity for too long a time so that surface damage ensues and the fatigue resistance falls. With chilled iron shot some limitation on intensity was imposed through the tendency of the shot to break up rapidly if conditions became too severe, but with the use of chopped wire shot, this automatic safeguard is no longer present. Zimmerli (1948) showed that over-peening can occur with too coarse shot and Bardgett and Gartside (1951) obtained a falling-off in fatigue limit after very long peening times on an 18–8 Austenitic stainless steel.

The somewhat academic point has occasionally been raised as to whether the improvement of the fatigue life of peened springs is due to the internal stresses induced in the bar or to the increased hardness of the cold-worked surface layer. In practice it is impossible to obtain the one without the other, but the authors' opinion is that for springs using torsional stressing (coil springs and torsion bars) the improvement is due to the increased hardness, while for springs using direct stressing (laminated springs) it is due more to the residual compressive stress. Justification of this is given in Appendix I, but the main point is that shot peening induces a plane compressive stress at the surface which is directly subtractive from the tensional stress of a laminated spring plate, but which combines with a shear stress at the surface of a twisted bar in such a way as would actually reduce the apparent torsional fatigue strength in the absence of any surface hardening, assuming that failure in fatigue under complex stresses occurs under the Shear-Energy Hypothesis which has been so well confirmed by the work of Gough (1949) at the National Physical Laboratory.

Prestressing, Scragging.—The operation of "scragging" springs has been in use for many years for improving the lives. The effect of this operation is to put a stress in the surface in such a direction that this stress is diminished by the action of the service stress. During the first scrag of a coil or laminated spring, or the first twist of a torsion bar, the surface material is loaded well beyond its yield point; plastic flow occurs to a depth by an amount depending on the degree of loading, and, on release of the external load, a residual stress is left in the bar.

The subsequent load-carrying capacity of the spring depends on the amount of this residual stress, but its stability in dimensions is also dependent to some extent on the number of times the scragging is done. Strictly speaking, the spring should be loaded and unloaded for as many times as may be needed to obtain a cyclic condition, for after the first loading the limit of proportionality of the material is actually reduced and plastic set in the second loading will occur earlier than it did in the first, although the amount is much less. However, over 95 per cent of the total attainable set is usually complete after three scrags, and this should be the minimum number used in production.

Speaking very broadly, the more the spring is scragged the better. However, the degree of scragging which can be given to a coil-spring is evidently limited on the one hand by the height to which the spring can be coiled without causing buckling and bending in the scragging operation, and on the other by the complete closure of the spring. For a torsion-bar there is no such limitation, and any degree of scragging, short of actually breaking the bar, can be given. However, the stress-strain curve in torsion tends to flatten out at about a surface shear strain of 0·025 radian, and little advantage is gained by going any further. The practice in America, as recommended in an S.A.E. pamphlet (1947) on torsion bars, is to twist up to a surface strain of 0·022 radian, which gives a residual surface strain of about 0·006–0·008 radian, and for which the plastically deformed material penetrates to about half the radius.

In making the above generalisation "the more scragging the better," it should be borne in mind that at very large amounts of scragging some surface damage may set in. Indeed, on a carbon spring steel, Pope and Andrew (1949) showed that for residual surface shear strains greater than about 0·008 radian another type of internal stress was introduced which had the effect of offsetting some of the beneficial stresses. They referred to these as "textural stresses," and their origin and nature is still obscure, but unfortunately the authors have no information as to the amount of scragging which can be give to silico-manganese steel bar before such stresses appear.

For a coil-spring the problem of the optimum degree of scragging is a little more complicated. Since the required spring-rate and the working length generally fix the size of the spring (that is, bar size, diameter and number of coils), the only other variables under our control are as-coiled height (that is, height before scragging) and the hardness level, from which the torsional L.P. can be roughly estimated as about 0·088 times the Brinell hardness for silico-manganese heat-treated to about 380–480 Brinell. There is also the added complication that the stresses are not uniform round the bar, but are largest along the innermost side of the spring coil, the amount being usually calculated from the nominal stress by the application of various "factors" involving the bar size and spring diameter, the commonest being that due to Wahl (1944). Moreover, Wahl's correction was calculated on the assumption of purely elastic conditions and does not allow for the possibility of plastic flow.

In general, the determination of a reasonable as-coiled height is based on experience and trial and error, but in order to be more systematic we may have recourse to a useful method based on that described by Sopwith (1947), who took a series of coil springs (rectangular section bar as well as circular section are considered, but the latter is the only case of interest here), applied different scragging loads, recorded the deflections and obtained an empirical relationship between the two. It is convenient to work in terms of stresses, fully corrected by a curvature factor (although nominal in the sense of being based on the assumption of pure elasticity even when plastic set is known to have occurred) and Sopwith found that a reasonable fit to the curves was given by

$$\frac{r}{p}=2-\frac{p}{q}$$

where p=stress at the initial limit of proportionality, or when the spring is just beginning to take a permanent set, q=nominal stress under the scragging load, calculated from the deflection, assuming elasticity and correcting for curvature, and r=elastic range of stress after scragging, that is, after unloading the stress set up by reloading to the same height as under the scrag, again calculated from the deflection (equal to the new free height minus the height under the scragging load).

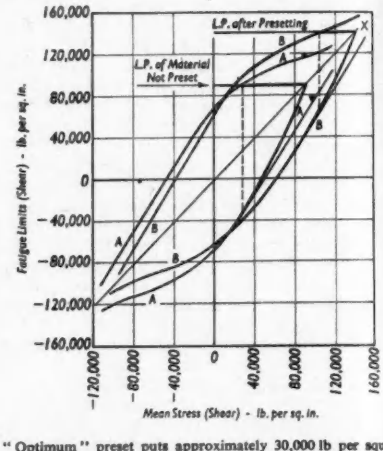
For use in this formula, p is about 55 tons per square inch, which is much higher than the L.P. found in torsion tests, due to the fact that the "fit" of the formula is worst for small amounts of permanent set. "r" is generally given by the designed free height of the spring after scragging together with the known height of the spring at closure. From these two then, q can be obtained from the formula and hence using the known spring-rate the as-coiled height before scragging can be determined.

It should be noted that this method gives the height to which the spring must be coiled to give the specified final dimensions. It does not necessarily give the optimum conditions of scragging.

For leaf springs, the determination of the preset camber is still largely a matter of trial and error, and so far as the authors are aware no thorough investigation of this point has been made. However, the number of variables in a leaf spring assembly are so many that it is doubtful if a really useful purpose would be served by the inevitable complication that a formula would involve.

Fatigue Data on Shot-peened and Preset Springs.—The general layout of the fatigue limit diagram for various ranges of torsional stresses is shown in curve *A*, Fig. 3. Evidently the curve for negative mean stress is the same as the one for positive and negative torsional stress, since there is no physical difference between positive and negative shear stress. However, the effect of prestressing, that is, introducing a prior positive shear stress in the surface, and neglecting for the moment any possible work-hardening effect of the plastically deformed layer, would be to shift the whole curve along the line *OX* by an amount corresponding to the amount of the initial stress, giving the new curve *B*. The position of *B* in relation to *A* shows the well-known fact that the fatigue ranges for negative mean stresses are considerably reduced, and also that they are reduced even for positive mean stresses up to a certain value beyond which the fatigue range is improved.

From various published and private results of fatigue tests, the positive-mean-stress half of the diagram is shown re-drawn quantitatively



"Optimum" preset puts approximately 30,000 lb per square inch residual stress in surface. Curve *B* is obtained from *A* by shifting the latter along *OX* by 30,000 lb per square inch.

▼ Fatigue limits of original material, assuming all permanent set taken up and stress held constant.

Fig. 3—Fatigue Limit Diagram

in Fig. 4, with stress-range plotted against mean stress. Curve *A* refers to "safe" stresses for 300,000 cycles of stress unbroken, on silico-manganese steel, undecarburised, shot peened, heat-treated to 430 minimum Brinell in sizes between ⅜in and ⅝in diameter, the usual range for automobile springs. Curve *B* refers to the same steel given an "optimum" presetting treatment, that is, such as to develop 0·008 residual surface strain, or about 30,000 lb per square inch surface shear stress. As mentioned previously, the effect of any possible work-hardening is neglected, but this would, if anything, improve the "safety" of the figures. Fig. 5 gives exactly the same data but with the minimum stress of the range plotted against the maximum stress of the range.

It is emphasised that these diagrams are put forward very tentatively, since they are based on not very consistent results, in the hope that the various automobile manufacturers who possess more detailed fatigue data will be able to criticise them in the light of their experience.

Corrosion and Corrosion-fatigue.—Unless springs are adequately protected during service,

the surfaces will become rusted and pitted. There is a vast body of evidence to show that under these conditions the fatigue resistance will drop by very large amounts, and, in fact, there may not even be any fatigue limit at all.

Unfortunately, there does not appear to be any published data on the corrosion-fatigue properties of silico-manganese steel, so far as the authors are aware. Consequently all the remarks which follow are based on results on

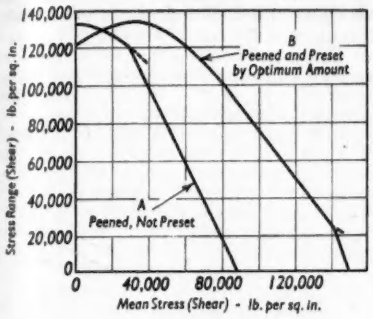


Fig. 4—Positive Mean Stress Diagram

various other materials, and thus apply only in a qualitative sense to spring steel.

Under corrosive conditions, the usual *S-N* curve generally does not run to a horizontal limit after a large number of cycles, as in most ordinary tests, but continues to fall as the applied load falls and the cycles to failure increases. However, the majority of laboratory corrosion-fatigue tests are made in relatively highly corrosive conditions, such as a continual drip of water or salt-solution, whereas a spring, if the protection broke down, would be exposed to the ordinary damp atmosphere, unless it is actually splashed in some way. The deterioration may thus not be quite as bad as corrosion-fatigue tests might lead one to believe.

Gough and Sopwith (1937) showed that fatigue tests in vacuum gave distinctly better results than those in air; for example, the rotary bend fatigue limit of a cold-drawn 0·5 per cent carbon steel rose from ±21·4 tons per square inch in air to ±22·3 tons per square inch in vacuo. Thus, if the spring is coated with any material which, while not attacking the steel, will exclude air, an improvement in fatigue properties might

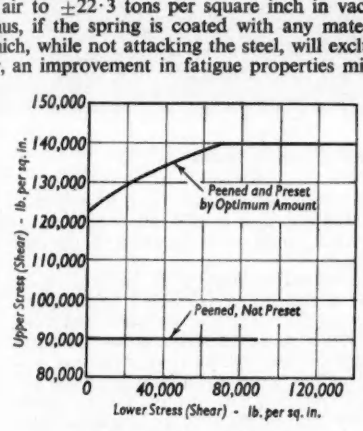


Fig. 5—Shear Stress Diagram

be expected. Cazaud (1953) reported tests on duralumin with an impervious plastic coating for which the fatigue limit rose from ±12·5kg per square millimetre in air without protection to ±13·5kg per square millimetre with the coating.

There have been many coatings and surface treatments devised to prevent corrosion attack on springs, including phosphating, galvanising, aluminium spraying, &c., and all are quite effective in combating corrosion-fatigue in air. Gough and Sopwith tested a large number of such methods, using a 0·5 per cent carbon steel, both drawn and normalised. The fatigue limit in air varied between about 90–100 per cent of the "unprotected" fatigue limit, but without any consistent indication of the superiority of any one method of protection. When the specimens were tested in a salt spray the fatigue limits showed considerable variation, because of the variable ability of the coatings to resist such drastic conditions. Actually galvanising and sherardising gave the best performance, closely followed by aluminium spraying and subsequent enamelling. The worst performances were given by phosphating and enamelling, but the very severe conditions must be borne in mind before too much importance is attached to this.

Conclusions

Although this paper has been devoted to steel springs of types and finishes already in use, the authors do not preclude the possibility of further developments in either. Whatever changes the future has in store, if steel springs are used to carry weight by virtue of the elastic properties in the steel, the comments which have been made will still be fundamentally applicable.

The authors are aware of the fact that research into the use of materials other than steel for making automobile springs is going on, but it is not within their power to forecast the extent to which they will become popular. Steel springs will continue to provide good service whilst the demand is there as they have done in the past.

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A 102in Water Main for M.W.B.

At a recent meeting of the Metropolitan Water Board, approval was given to a recommendation of the works and stores committee that authority be given to the laying of the proposed raw water main from Hampton to the Lee Valley reservoirs as a 102in gravity main and not a 75in pumping main as approved in November, 1949.

The agenda paper in which this recommendation was made gave an interesting *resumé* of the scheme. It recalled that in a report in December, 1948, there was recommended the laying of a main of about 60in diameter, partly in trench, but mostly in tunnel, to convey unfiltered Thames water from Hampton to the Lee Valley reservoirs. The estimated cost of the scheme amounted to £3,855,000, inclusive of the purchase of the necessary land and easements, but exclusive of the provision of pumps and a pumping station which it was intended to construct at Hampton, and of the construction of an intake, &c., at Hampton works. Authority was also given for arrangements to be entered into with Sir William Halcrow and Partners with a view to their undertaking the surveys, preparation of the necessary plans, &c., and the design and supervision of the construction of the main.

As a main of this type had not been laid before in London, it was decided that a trial length of approximately 1000ft should be laid at Barn Elms works at an estimated cost of £43,000, in advance of the construction of the complete main, in order to ascertain the difficulties which would have to be overcome and to obtain information upon which the specification and contract documents for the laying of the main itself could be based.

A year later, in the light of the reduced yield from the River Lee during the drought of 1949, and of the desirability of postponing the date by which it might become necessary to lay a duplicate main to meet anticipated increased demands, authorisation was obtained for the laying of a 75in instead of a 60in main at an additional estimated cost of £1,090,000. It was also decided that the trial length of main should be laid in the Board's works at Stoke Newington instead of at Barn Elms as previously authorised, the former being a more suitable site for the purpose.

By August, 1951, the laying of the experimental length of main had been completed. After the tunnel had been lined with wedge-shaped concrete blocks, known as "Donsegs," concrete-lined steel pipes, 75in in diameter, were pulled into it. The pipes, ¼in in thickness, had internally welded joints and the annular space between the outside of the pipes and the concrete lining of the tunnel was filled with cement grout. For about 90ft of the experimental length pipes of a thickness of ¼in were used, and they were lined with cement mortar applied *in situ*. It will be appreciated that in this design the pressure of the water is intended to be carried by the steel pipes and not by the concrete lining to the tunnel or the clay which surrounds the lining.

In October, 1951, in connection with the construction of the filtration works at Ashford Common, an opportunity occurred for the carrying out of a further "pilot" scheme for the laying of a large diameter main in tunnel. It was necessary to drive a tunnel of 100in internal diameter for a distance of about 630 yards through the clay from the outlet of the Queen Mary reservoir to supply stored water to the filters under construction at the new works. The tunnel was lined with "Donsegs" and, after much consideration, it was decided to dispense with a steel pipe for carrying the water, and, unlike the case of the experimental length at Stoke Newington, to rely on the weight and strength of the clay surrounding the concrete lining to the tunnel to withstand the pressure of water passing through it.

The tunnel was completed in November, 1952, and no disadvantage has so far accrued from this design. Elaborate measurements have been made to ascertain the behaviour of this particular form of lining under the pressures of the water and the overlying ground, and the results to date have justified the decision to omit the steel pipe.

Revised Proposals for Thames to Lee Valley Main

In the light of the experience gained at Stoke Newington and Ashford Common, attention was directed to designing the main from the Thames to the Lee Valley so that it could be constructed without a steel lining and consequently at a reduced cost. After a careful review of the whole position, the following revised scheme

was submitted for the Board's consideration last week.

It is now proposed that the main shall be constructed in tunnel in the clay at such a depth as to render unnecessary, except perhaps at river crossings and in certain localities, the use of an inner lining of steel pipes or a lining of cast iron segments. The depth of the tunnel would be such that water will flow by gravity, under the head of the River Thames, from the intake at Hampton to a shaft to be constructed near Lockwood reservoir at Walthamstow, in the Lee Valley. It is proposed to convey 70 m.g.d. of water through the main and, to enable the water to flow by gravity, it will be necessary to construct the main of a nominal internal diameter of 102in. The use of steel pipes will be almost entirely dispensed with, and, as compared with the original proposals, there will be a saving of some 20,000 tons of steel. The tunnel, which will form the main, will be constructed of concrete segments lined with cement mortar. At the Lockwood reservoir site electrically driven pumps, operated by purchased current, would be installed to lift the water into the Lee Valley reservoirs and, on the assumption that it will be possible to use submersible pumps, no provision would be made for a building. No standby to the pumps would be provided, in view of the high cost of diesel-driven plant, as, in the event of a failure of the electricity supply, it should be possible to maintain the water supply in the east of London by drawing down the Lee Valley reservoirs. Two 54in mains would be provided through which the water could be pumped from the Lockwood reservoir site northwards, one discharging into the High Maynard reservoir and the other terminating at the proposed Chingford South pumping station, whence the water could be pumped into either the William Girling or the King George's reservoir. Connections would be provided into both Banbury and Lockwood reservoirs.

PROVISION FOR FUTURE INCREASE IN CAPACITY OF THE MAIN

At some future date it may be necessary to increase the flow through the main to 120 m.g.d. by the use of booster pumps. Accordingly it is proposed to construct at Barn Elms the appropriate branches and shafts so that pumps can be installed, if necessary. If such pumps were installed it might be found necessary to line some 2 miles of the main with steel, owing to the additional pressure to which the main to the east of the station would be subjected. The present main will be designed in such a manner that this length of steel lining could be inserted at the minimum of cost and inconvenience. If the flow were to be augmented in the future by 50 m.g.d., it would also be necessary to install additional pumps at Lockwood, and in designing the main, regard will be had to this possibility. No provision has been made in the estimate for the cost of possible booster pumps at Barn Elms and additional plant at Lockwood.

The total estimated cost of the revised proposals amounts to £5,120,000, which is £175,000 in excess of the sum of £4,945,000 already approved, but the revised design is appreciably cheaper than the earlier scheme.

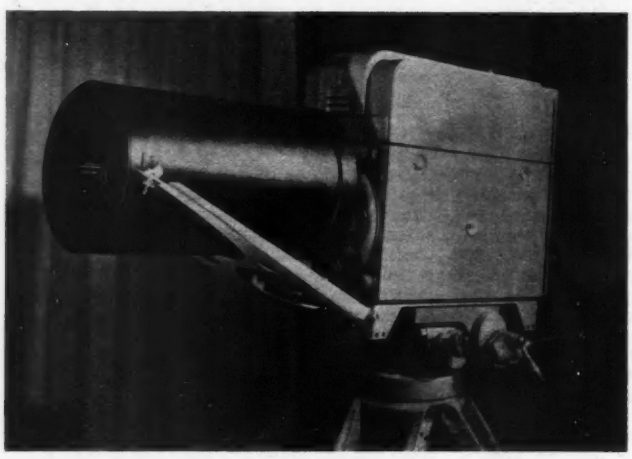
A Long-Focus Lens for Television Cameras

A NEW long-focus lens for television cameras is now on loan to the British Broadcasting Corporation by Marconi's Wireless Telegraph Company, Ltd., Chelmsford, Essex. It has a focal length of 80in and was used during the televising of the recent Ascot race meetings on June 18th and 19th.

Its magnification is twice that of the existing 40in lens, three of which the company supplied to the B.B.C. earlier this year. During one test of this lens, the lattice work of an aerial mast 3 miles away was shown on the monitor screen in clear detail.

The idea of producing an even larger lens originated when a B.B.C. official returned from the United States after having seen a 60in lens in use on a television camera. Marconi Wireless Telegraph Company was asked to assist and, in co-operation with the optical firm of Cox, Hargreaves and Thomson, Ltd., devised the new lens. The designers decided to adopt the Cassegrain reflecting system—which is only suitable for focal lengths exceeding 60in. A reflecting system is more practical than a refracting one because of better weight distribution and because there is no danger of chromatic aberration.

The new 80in lens, which can be seen in the accompanying illustration, consists, very briefly, of two reflecting surfaces, the main mirror being concave and the secondary convex. By suitable proportioning of the curvature of the convex mirror a "telephoto" effect is achieved, and because of the arrangement of the mirrors in this case the overall length of the entire piece of equipment is only 20in. Again, because of the arrangement of the mirrors, the main body acts as a protective hood. The total weight is about 20 lb. There is mechanical control of the aperture through which light passes from the lens into the camera.



80in Focal Length Lens for Television Cameras

LIGHT ALLOY SLUDGE SCRAPERS.—We are informed that the six sludge scrapers recently installed at the Nottingham Corporation sewage disposal works, each have a span of 114ft 4½in and were constructed of duralumin "H" light alloy sections and plates, supplied by James Booth and Co., Ltd., by Thatcher Lucas and Co., Ltd.

Railway Roof Inspection Ladder

FOR the inspection of very high station roofs a self-supporting turntable ladder, which can be extended to a height of 65ft, has been constructed for British Railways (London Midland Region). Besides making inspection speedier, it will obviate the need for the erection of scaffolding.

The ladder was built by Messrs. Merryweather and Sons, of Greenwich, in conjunction with British Railways (London Midland Region) and is designed to fulfil a dual role—as a ladder which could be operated from a station platform and also as a mobile unit which, mounted on a truck, could move anywhere on the railway system.

65ft Turntable Ladder

The inspection ladder was designed to rotate in any direction and to reach a height from the ground of 65ft. The fulcrum frame which carries the ladder is mounted on a low steel frame carriage on four rubber-tyred castoring wheels. Four folding, screw-down jacks are fitted so that when in position they give the ladder four-point stability and enable it to be operated within a wide range of angles of elevation in perfect safety. The ladder itself is in three nesting sections (one main ladder and two moving sections), all of steel tubing of special section.

All movements of the ladder are carried out by specially designed hand-operated gear. A double-purchase hand winch controls elevation and has an automatic over-run safety brake and pawl. The winch is connected to the heel of the ladder by a wire rope system, and operation of the winch draws the heel of the ladder inwards until the desired angle of elevation is reached. The ladder extension gear also has an automatic over-run brake, the ladders being controlled by pawls which also serve to register the rungs in line and to take the weight from the extension gear. The two moving sections of the ladder extend in unison by the wire rope system.

The turntable frame, being mounted on a roller bearing path, is easily turned throughout 360 deg. by a worm-gear operated by a handle. At the head of the top ladder is a small platform on which the inspector can stand.

Industrial and Labour Notes

Monopolies Commission Bill

On Wednesday of last week, a first reading was given in the House of Commons to a Monopolies and Restrictive Practices Commission Bill which the Government has introduced. The purpose of the Bill is to strengthen the Monopolies Commission to enable it to deal at any one time with a greater number of references.

To that end, three principal changes are proposed. In the first place, the Bill provides that the chairmanship of the Commission shall become a long-term pensionable appointment and that the Board of Trade shall be empowered to appoint up to two deputy chairmen, also on a long-term pensionable basis. The second proposal in the Bill is that the maximum membership of the Commission shall be increased from ten to twenty-five. Thirdly, it is proposed that the functions of the Monopolies Commission shall be exercisable by groups of not less than five members. In relation to any reference remitted to it by the chairman, a group will have all the powers and duties assigned to the Commission under the Monopolies Act and its report will be a "report of the Commission" for the purposes of that Act. No conclusion in a group report, however, will empower the Government to take remedial measures under the principal Act unless it is the conclusion of at least two-thirds of the members of the group.

The new Bill, therefore, relates only to the constitution and organisation of the Monopolies Commission. It does not in any sense modify the powers and duties of Government departments under the Monopolies Act, or the statutory conditions governing the making of references.

Social Security Schemes for Miners

The National Coal Board has published this week the first report of the mineworkers' pension scheme which was established on January 1, 1952. With it there are included reports of the two colliery workers' supplementary industrial injuries schemes and the special fatal accidents scheme. All the schemes are administered by joint committees composed of representatives of the National Coal Board and the unions.

The report explains that membership of the pension scheme is voluntary, but just over 80 per cent of those eligible to do so have now joined. The proportion varies considerably in different areas, in Yorkshire, for example, the membership being only 58 per cent of those eligible, compared with 93 per cent in Northumberland and Cumberland. The report covers the period January 1, 1952, to April 5, 1953, during which time members' contributions amounted to £2,235,717. The National Coal Board's contribution is 3·5 times the members' share. The number of pensions being paid on April 5th last was 13,202, their total annual value being £366,540. In addition, 5691 lump sum benefits had been awarded to a total value of £62,210. On April 5th the value of the fund stood at £9,870,468, and the report says that it is bound to grow at a considerable rate for many years. On the basis of present membership, it is stated, the fund may ultimately well exceed £200,000,000, with 150,000 ex-miners, 100,000 widows and 30,000 children drawing benefit.

Tinplate Prices

The Minister of Supply has made the Iron and Steel Prices No. 3 Order, 1953, relating to tinplate prices. An explanatory note to the Order says that it increases the basis price for tinplate by 1s. 1d. per basis box, and for tin coating extras by corresponding amounts. In consequence, however, of the price reduction resulting from the operation of the "automatic variation adjustment" for tin, the maximum permitted selling prices for tinplate will not be changed. The purpose of the Order, which has been made with the agreement of the principal tinplate consumers, is to stabilise temporarily the maximum selling prices of tinplate, pending a detailed examination of the price structure of the industry. The Order took effect on July 1st.

Industrial Production

In its monthly review of the economic situation, the information division of the Treasury has stated that the recovery of industrial production as a whole from last year's setback is now complete, although in some industries output is still below the levels of 1951. In the first four months of this year, the review says, total industrial output was 1¼ per cent higher than in the corresponding period of last year, but was, nevertheless, only just back to the 1951 figure. Factors in this recovery, it is suggested, are the high level of production in non-manufacturing industry—particularly building and contracting and the public utilities—and marked revivals in the textiles and vehicle manufacturing groups.

Dealing specifically with capital goods, the review says that the output of machinery has been limited by lower export demand and shipbuilding by the shortage of steel plate. Motor-car output, however, stimulated by larger home sales and rising exports, has fully recovered. The shortage of steel plate, the review continues, shows at its clearest in shipbuilding, and though completions this year have been maintained at last year's rate, the tonnage laid down has fallen 8 per cent below it. At the end of April, nearly 2,000,000 gross tons of ships were under construction, of which just under one-third was for export. In the middle of last year a decline in orders for ships set in, but this was to be expected after the heavy influx of orders in 1951 and the early part of last year, which broadly booked up capacity for several years ahead. At the end of April, total orders for ships amounted to about 6,250,000 gross tons, of which two-fifths was for export.

Exports of machinery have fallen well below last year's levels and in the first quarter the volume exported was 17 per cent less than in the comparable quarter of last year. The Treasury's review suggests that this has played an important part in bringing total output down. The output of some kinds of equipment, such as industrial trucks, pumps and refrigerating plant, has continued to rise, but it seems likely that in the first quarter of this year the total volume of plant and machinery produced was 6 per cent below that for the corresponding period of last year.

The Non-Ferrous Metals Industry

The annual meeting of the British Non-Ferrous Metals Federation was held in Birmingham on Thursday of last week. After his re-election as president, Mr. H. E. Jackson delivered an address which was in effect a report of the Federation's activities during the past year.

In the course of his address the president referred to the emergence from a sellers' market to a buyers' market for non-ferrous products. It had occurred, he said, in varying degrees, but the change had taken place over the whole range of the industry's products. It was, of course, inevitable, Mr. Jackson continued, that such a change should occur, but the first impact of the new circumstances had, none the less, been very disagreeable. The sellers' market had endured right up to the beginning of the Federation's last official year and until then a full demand had been pressing upon an inadequate supply. In those circumstances, Mr. Jackson commented, price was not the prime consideration governing the placing of orders. At the end of the year, however, supply had overtaken demand and the price mechanism was struggling to reassert itself. The year had seen the freeing of lead, tin and zinc from official control in this country and the decision to free copper. The last official price for lead on September 30, 1952, was £131 a ton and towards the end of April this year the price had dropped to £73 10s. In the case of tin the last official price on November 14, 1952, was £750 and, in June, this year it reached its lowest free price at £672 10s. When zinc was decontrolled on January 1st last, the controlled price was £110 a ton and by April the free price had declined to £63 10s. Whether, Mr. Jackson added, the price of copper would follow the trend of other metals on the reopening of the Metal Exchange to it was a matter of opinion. It was no doubt the belief that the reopening of the exchange would bring a substantial fall in the price of copper that had helped to cause the present grave recession of demand over the whole range of the non-ferrous metals industry's products.

Factory Problems

The Institute of Personnel Management has just published a booklet entitled *Some Problems of a Factory—An Analysis of Industrial Institutions*, which has been prepared by Mr. Wilfred Brown, managing director of The Glacier Metal Company, Ltd. A few years ago this firm undertook, in co-operation with the Tavistock Institute of Human Relations, a research into the managerial and social problems facing industry. One result of this research, it is stated, has been the emergence of some defined ideas and concepts stating the social processes in operation in the Glacier Company's factories. The booklet describes these ideas and concepts and claims that managers, technicians, shop stewards and staff representatives are patterning their behaviour upon them in dealing with the day-to-day technical, economic and administrative problems encountered in the course of the company's business.

The price of the booklet is 3s. It can be obtained from the Institute of Personnel Management, 8, Hill Street, London, W.1.

Training for Management

Last week-end the Industrial Welfare Society held its thirtieth annual conference at Keble College, Oxford, the general theme of the discussions being "Progress in Relations at Work," At one of the sessions a discussion on "Training for Management Succession" was initiated by Mr. A. B. Waring, chairman and managing director of Joseph Lucas, Ltd., who said that the future success of industry depended primarily on its ability to produce a succession of people possessing the right qualifications for successful management. Most of those holding senior positions in industry to-day, Mr. Waring asserted, would admit that they would have done their jobs better and avoided many errors had they had the advantage of some formal training to supplement their training in the hard school of experience.

Mr. Waring went on to emphasise the need to train and develop the best material to meet the changing social circumstances of industrial life and the rising standards of technical efficiency which were essential for the development of export markets in the face of world competition and for the improvement of standards of living. A policy of promotion on merit within an industrial organisation, he said, would encourage the best, but there should also be a leavening of outside recruits to introduce fresh outlooks. As to training for management, Mr. Waring advocated that the formal training was best carried out away from the man's job to enable him to broaden his outlook. But, he advocated, training must be continuous and progressive. It should be established as part of the routine, and managers at all levels should contribute something to the formal training of those of lower rank. To find the right candidates and to give them adequate training, Mr. Waring concluded, was the greatest contribution which management could make to the continued prosperity of its enterprise.

Notes and Memoranda

Rail and Road

INSTITUTION OF LOCOMOTIVE ENGINEERS' GOLD MEDAL.—The council of the Institution of Locomotive Engineers has awarded the Institution's Gold Medal (its highest award) to Mr. R. A. Riddles, C.B.E., member for mechanical and electrical engineering, the Railway Executive, for outstanding services in the advancement of locomotive engineering. The gold medal, which was first awarded in 1946 is awarded at the discretion of the council for special, or meritorious, services in connection with the profession of locomotive engineering, the presentation will be made at the opening general meeting of the 1953/54 session next September.

Air and Water

LAUNCH OF COASTAL MINESWEEPER.—H.M.S. "Beachampton," a coastal minesweeper of composite construction and having a length of 152ft by 28ft 9in beam, was launched from the yard of the Goole Shipbuilding and Engineering Company, Ltd., on Monday, June 29th.

FLEET COMMODORES.—The New Zealand Shipping Company, Ltd., and the Federal Steam Navigation Company, Ltd., announces that Captain G. Kinnell, O.B.E., the Master of the passenger liner "Rangitata," has been appointed Commodore Captain and that Mr. J. H. Anderson, the chief engineer, has been appointed engineer commodore.

JAPANESE JET ENGINE DESIGNING COMPANY.—The president of the Ishikawajima Heavy Industries has stated that his company, together with the Shin Mitsubishi Heavy Industries, Fuji Industries and Ruji Precision Industries, have established a company, to be called the Japan Jet Engine Company. This company would have a capital of about 160 million yen and is expected to begin work within two months. It had applied to the Japanese Government for subsidies to help development operations over the next two years. The company would be dissolved after the engines had been designed and tested and share-holding companies would begin manufacture.

WRECK RETURNS.—Lloyd's Register of Shipping has issued its returns of merchant ships totally lost, broken up, &c., for the quarter ended December 31, 1952. Of the world total of fifty-three steamships and motorships of 54,958 tons gross, lost consequent upon casualty, eleven ships of 4193 tons belonged to Great Britain and Northern Ireland and nine ships of 1902 tons to the other Commonwealth countries. The world total of steamships and motorships lost, not consequent upon casualty, amounted to ninety-five ships of 242,807 tons, including twenty-nine ships, representing 65,719 tons, owned in Great Britain and Northern Ireland, and one ship of 3286 tons belonging to the other Commonwealth countries.

Miscellanea

ADEN REFINERY.—The erection of the first refining plant has commenced at the 5,000,000 tons per year Aden refinery of the Anglo-Iranian Oil Company, Ltd., and over a million cubic yards of sand has dredged in the port area, while about 2500ft of the 4000ft-long breakwater have been completed.

TRAINING IN COMMUNICATION.—The British Association for Industrial and Commercial Education has issued a pamphlet giving information about the instructional courses made available by its communication training centre. The purpose of this centre is to assist in the improvement of all spoken and written communication within industry and commerce.

JOINT CONSULTATION BOOKLET.—The Industrial Administration Group of the Birmingham College of Technology recently organised a series of discussions on the working of joint consultation. The discussions were based on papers presented by acknowledged authorities on various aspects of joint consultation. These papers, together with a report of the discussions have now been published in a booklet which is available, at 3s. 6d., from the College of Technology, Birmingham.

ENGINEERING GRADUATE COURSES.—The University of Birmingham has published details of courses at a post-graduate level in metallurgy, chemical engineering and thermodynamics. These courses are normally of one year duration and are designed for graduates who have had some industrial experience. Each course comprises lectures, tutorial classes and laboratory work. The Diploma in Post-Graduate Studies is awarded on the satisfactory completion of each course. Further details of these courses may be obtained from the Registrar, The University, Edgbaston, Birmingham, 15.

VACATION SCHOOL ON ANALYSERS AND COMPUTERS FOR ELECTRICAL SYSTEMS.—A five-day vacation school to review analysers and computers for electrical systems will be held from July 13th to 17th in the Electrical Engineering Department of the Imperial College of Science and Technology, Exhibition Road, London, S.W.7. The school will be opened at 10 a.m. on Monday, July 13th, by Mr. F. J. Lane, transmission design engineer of the British Electricity Authority, and the subsequent programme will consist of nine lectures and discussions thereon. Primarily the school is intended for engineers who have some experience of electrical system problems and the inclusive fee will be eight guineas.

INSTITUTION OF WATER ENGINEERS.—The South-East Section of the Institution of Water Engineers inspected the new works of the Colne Valley Water Company during their summer meeting. The works visited were the Bricket Wood pumping station, the Hillfield Park reservoir and the Clay Lane treatment works. Raw water pumped from chalk wells will be stored in the reservoir, which will have a capacity of 540 million gallons and 24 million gallons per day will be purified at the treatment works. In addition to the works inspected the Colne Valley Water Company, which serves a population of 550,000, requiring a daily average supply of 23 million gallons, is to construct a covered reservoir to hold 25 million gallons of treated water.

HISTORICAL MAP EXHIBITION.—In view of the great interest which it has attracted, the Royal Institution of Chartered Surveyors has decided to continue for a further three weeks, until July 25th, its exhibition, "Five Centuries of Maps and Map-Making." In this exhibition a thousand maps, atlases, books and instruments portray the fascinating story of cartography and accurate surveying during the last five hundred years. Exhibits include many beautiful and interesting early maps and atlases, plans for early British canals and railways, hydrographic and aviation charts, a demonstration by the Ordnance Survey of the processes of modern map-making and a wide selection of modern maps and plans. The exhibition is open daily (except Sundays) from 10 a.m. to 8 p.m. at 12, Great George Street, Westminster, and the price of admission is 2s. 6d.

A WIND VELOCITY SIGNAL ANEMOMETER.—An improved anemometer which is designed to give audible and visual warning when the wind reaches a predetermined speed is now being made by R. W. Munro, Ltd., Cline Road, Bounds Green, London, N.11, for installation on large cranes, structures, &c. The apparatus consists of a cup anemometer housing a speed contactor, a warning light box and an electric horn. The anemometer is mounted on a mast raised above the building or superstructure to catch the undeflected wind stream. The wind speed at which a warning is to be given is obtained by the adjustment of a pointer on a speed scale in the anemometer housing. The warning light box can be fixed at any convenient position, and its cover has one red light window and a white light window, the former will show red when the predetermined wind speed has been reached. The white light shows that current is "on" and the system is working.

SUMMER SCHOOL FOR FOREMEN.—The Institute of Industrial Supervisors is arranging a summer school for foremen, which will be held at Dillington House, near Taunton, from September 3rd to 10th. The school will include three of the Institute's short residential courses and the programme is designed so that each of these courses may be taken separately if desired. Each course is designed to be of direct and practical help to foremen with plenty of opportunity of exchanging experience and ideas with people from other companies and industries. This exchange is stimulated, whenever appropriate, by the use of specially developed case studies and practical exercises. The three courses which it is proposed to present during the week are "The Practice of Supervisory Management," "Industrial Relations and Industrial Law—What the Foreman Should Know," and "Work Study for Supervisory Management." Details of the school can be obtained from the Institute of Industrial Supervisors, Bank Chambers, 47, Temple Row, Birmingham, 2.

SPECIALIST QUALIFICATION FOR SANITARY INSPECTION.—The Royal Sanitary Institute has instituted a new examination in the inspection of water and drainage installations. This examination is intended to satisfy a demand for inspectors with specialised knowledge and experience who would be able to maintain a higher standard of inspection and approval of all types of water and drainage installations than those with more general qualifications and duties are normally in a position to effect. The examination will be of interest to those concerned with the design, construction or inspection of water, drainage or plumbing installations who desire a specialist qualification as inspectors of water and drainage installations. The syllabus includes water and water supply, drainage, disposal of sewage and removal of refuse, sanitary appliances and waste plumbing, law and administration, reports, tests and co-operation. Regulations and syllabus of the examination can be obtained from the secretary, Royal Sanitary Institute, 90, Buckingham Palace Road, London, S.W.1.

THE HARRISON TIMEKEEPERS.—We are informed that for the first time since the late war, all four of the Harrison timekeepers are at work again at the National Maritime Museum. Before September, 1939, these chronometers were kept running in the Navigation Room of the National Maritime Museum, but during the war they had to be stored and at the end they all needed cleaning before they could be exhibited again. This cleaning was undertaken by the Admiralty, to which the chronometers belong, and as each was finished it was sent back to the museum. Now the last to be tackled, No. 3, has been returned to its case, and all four can be seen working. In was in 1714 that the British Government first made an offer of a prize of £20,000 to whoever should solve the difficulty of how to determine the longitude within suitable limits. If a clock could be made to go sufficiently accurately at sea this would provide the solution. In 1735 John Harrison produced his first instrument weighing 73 lb. This gave some promise in a trial at sea and was followed in 1739 by the 103 lb No. 2, and No. 3, another large machine, was completed in 1757. Two years later Harrison produced his masterpiece, No. 4, which, completely different in appearance from its forbears, resembled a watch 5in in diameter. In 1761 it was tried on a voyage to Jamaica and on arrival found to have an error of five seconds only.

Personal and Business

ELECTRO METHODS, Ltd., states that its address is now Caxton Way, Stevenage, Herts (telephone, Stevenage 780).

SHORT BROTHERS AND HARLAND, Ltd., announces the establishment of an auxiliary planning office at Rochester Airport, Kent.

MR. F. J. THOMPSON has been appointed commercial manager of the Express Lift Company, Ltd., in succession to the late Mr. A. E. Hunt.

BOULTON PAUL AIRCRAFT, Ltd., announces that Mr. H. C. W. Trapmore has been appointed production manager of the company's works.

THE HARLAND ENGINEERING COMPANY, Ltd., states that Mr. G. S. Ramage, who has been secretary to the company since 1923, has been appointed a director.

THE MARCONI INTERNATIONAL MARINE COMMUNICATION COMPANY, Ltd., announces the appointment of Mr. W. A. Penkman as manager of the service division.

SAUNDERS-ROE, Ltd., states that Mr. Hugh Gordon has been appointed as general manager of the company's helicopter division at Eastleigh and will take over his post on July 13th.

SCOTT'S SHIPBUILDING AND ENGINEERING COMPANY, Ltd., states that Mr. G. Hilton, the shipbuilding manager, and Mr. J. R. Duncan, the engineering manager, have been appointed directors of the company.

MR. E. D. E. ANDREWES, a director of Tube Investments, Ltd., and until recently managing director of T.I. (Export), Ltd., has been appointed joint managing director of Accles and Pollock, Ltd., Oldbury, which is a member of the T.I. group.

HARLAND AND WOLFF, Ltd., announces that Mr. Louis W. Dunlop, J.P., has retired as manager of the company's Govan shipyard and has resigned his seat on the board and that he has been succeeded as manager by Mr. Charles Simpson, M.B.E.

FINA PETROLEUM PRODUCTS, Ltd., states that Mr. F. Banks Warner, the chairman and managing director, has retired but remains a director of the company and that Mr. C. M. Merrick, previously the joint managing director, is now the managing director.

THE GAUGE AND TOOL MAKERS' ASSOCIATION states that the Association's telephone number has been changed from Regent 3451/2 to Hyde Park 3451/2, and that the address remains as before as Standbrook House, 2-5, Old Bond Street, London, W.1.

BABCOCK AND WILCOX, Ltd., announces that a new company, Babcock Hitachi Kabuohiki Kaisha, has been established in Japan, to take the place of Toyo Babcock K.K., at the following address: Tokiwabashi Office, 5, 2-Chome, Ote-Machi, Chiyoda-Ku, Tokyo.

MR. K. S. PEACOCK has been elected chairman of Guest, Keen and Nettlefolds, Ltd., in succession to Mr. J. H. Jolly, who is retiring. Mr. Jolly will continue to serve as a director. Mr. Peacock was appointed a managing director of the company in 1936 and deputy chairman in 1950.

THE ANGLO-IRANIAN OIL COMPANY, Ltd., announces that Mr. A. W. G. Trantor has been appointed general manager of the Aden refinery and has been succeeded as works manager of the Kent Oil Refinery in the Isle of Grain by Mr. A. Patrickson, formerly the process superintendent of the refinery.

THE MINISTER OF EDUCATION has appointed Sir Frederick Handley Page to be chairman of the governing body of the College of Aeronautics, Cranfield, in succession to Air Chief Marshal Sir Edgar Ludlow-Hewitt, who has retired after more than eight years in office as the first chairman of the College.

HENRY MEADOWS, Ltd., announces that Major-General Sir Richard Lewis, K.C.M.G., C.B., C.B.E., Mr. Edgar W. Percival, and Mr. A. Wood, managing director of C. E. Johannson, Ltd., have joined the board of the company and that Mr. F. H. Harris and Mr. E. H. L. Cooper have been appointed joint general managers.

THOMAS SUMMERSON AND SONS, Ltd., Darlington, states that Mr. Roland Winn, secretary, has been appointed a director of the company. Mr. A. F. Tosh, works manager of Summerson's Foundries, Ltd., has been appointed a director of that company, and Mr. C. Whitehouse, works manager of Summerson's railway workshops at Spennymoor, has been appointed a director of Copelaw Engineering Company, Ltd. Mr. G. V. Newlands has been appointed works engineer of Thomas Summerson and Sons, Ltd., on the retirement of Mr. Walter Scott.

VICKERS, Ltd., announces that, owing to continued ill health, Major Sir Hew Kilner has found it necessary to relinquish his seat on the board of the parent company and the subsidiaries, Vickers-Armstrongs, Ltd., and Cooke, Troughton and Simms, Ltd. Major-General C. A. L. Dunphie has been appointed deptuy chairman and managing director of Vickers-Armstrongs, Ltd. The company's activities are now organised in three divisions, namely, aircraft, engineering and shipbuilding. Mr. P. H. Muirhead has been appointed managing director and Mr. P. H. Laurens, deputy managing director, of the engineering division, and Mr. G. H. Houlden has been appointed managing director of the shipbuilding division. Mr. R. P. H. Yapp has been appointed chairman of Cooke, Troughton and Simms, Ltd.

British Patent Specifications

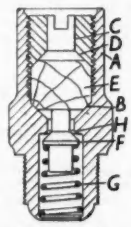
** When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application : the second date, at the end of the abridgment, is the date of publication of the complete specification.*

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

VALVES

692,516. January 22, 1951.—AIR RELEASE VALVES, Lily Jorgensen, "Sunicroft," Birmingham New Road, Tividale.

The invention relates to air release valves for use in hot water circulating systems and has for its object the provision of an automatic air release valve. Referring to the drawing, a hollow metal body *A* secured to a pipe system has formed in it an annular seating *B* of bevelled form. In the open outer end of this part is screwed an annular gland nut *C* having at its inner end a seating *D* complementary to that in the body. Between the two seatings is set the permeable closure member *E*. This consists of a disc or a short cylindrical piece of wood, such as pinewood or greenheart, the end faces of which may be bevelled corresponding to the seatings. The closure member is such that it is relatively easily permeable by air. But its permeability by water is sufficiently less, so that any water seeping slowly through it is evaporated by contact with the outer atmosphere. Where the system operates under a low-pressure head of water a pinewood closure member is satisfactory, greenheart being more convenient where the pressure head is relatively high. As wood is slightly compressible, the rate of seepage of water can be controlled by tightening the gland nut. Preferably, the body part has also combined with it a supplementary closure means in the form of a poppet valve *F* loaded by a spring *G*, by which the outlet of the body is closed when the porous closure member is removed, the valve being normally held off its seating *H* by the closure member. —*June* 10, 1953.

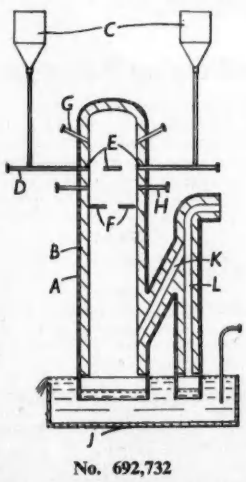


No. 692,516

GAS PRODUCERS

692,732. December 20, 1950.—CONVERSION OF CARBONACEOUS MATTER INTO USEFUL GAS, C. D. Patents, Ltd., 19, Berkeley Street, London, W.1 (formerly of 140, Battersea Park Road, London, S.W.11). (*Inventors : Arpad Artur Josef Kazimierz Eskreiss and Walter Buse.*)

The drawing shows in vertical section one form of apparatus embodying the invention. The vertical steel cylinder *A* is lined with refractory material *B*. The fuel from supply vessels *C* and the air or oxygen from supply conduits *D* are directed inwards through burners *E* horizontally in the form of fan-shaped flames. At a lower level burners *F* at intermediate points in the circumference of the cylinder



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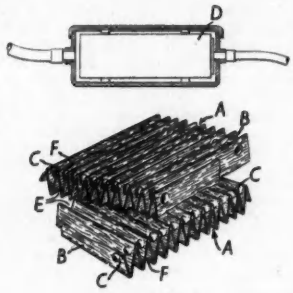
are similarly fed by suitable conduits to form overlapping flames which occupy the whole cross-sectional area within the cylinder. Inlets for steam and/or carbon dioxide *G* are arranged above the upper burners *E* and further inlets for steam and/or carbon dioxide *H* may be arranged between the two levels of burners. The cylinder is sealed at the bottom by circulating water in a tank *J* in which the solid products of combustion are caught. The gaseous products of combustion are led off through offtake *K*, a vertical branch *L* of which is also water-sealed within the tank. Various modifications in design and methods of firing are also shown in the specification.—*June* 10, 1953.

FILTERS AND STRAINERS

692,756. July 31, 1951.—FILTERING ELEMENTS, PurOlator Products, Inc., 970, New Brunswick Avenue, Rahway, New Jersey, U.S.A. (*Inventor : Julius Paul Kovacs*)

From the drawings it will be seen that the filtering element consists essentially of two units *A*, each composed of a strip *B* of filtering material pleated or folded as shown. The successive pleats of each strip are formed with offsets *C*. The two units are arranged in a rectangular enclosing frame *D* of such dimensions that the offsets *C* of successive pleats of each strip inter-engage and the spacing between successive pleats is determined by the height of the offsets.



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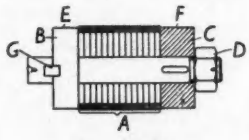
The arrangement of the units within the frame is such that the inner or facing folds of the pleats of one unit extend at right angles to and in contact with the inner or facing folds of the pleats of the remaining unit. The inner or facing folds of the pleats of the two units lie substantially parallel in crossed relationship. The edges of each strip are attached to the walls of the frame, thereby forming two sets of oppositely facing pockets, *E* and *F*. The end pleats of each strip are also attached to the walls of the frame *D*. The pockets *E* of each unit *A* face toward the pockets *E* of the other unit while the pockets *F* of each unit face away from the pockets *F* of the other unit. The inlet and discharge pipes are arranged at the ends of the frame as shown.—*June* 10, 1953.

WORKSHOP TOOLS AND APPLIANCES

692,906. September 11, 1951.—MANUFACTURE OF PISTON RINGS, Fritz Isler, 26, Weidstrasse, Rüschlikon, Zürich, Switzerland.

The invention relates to the manufacture of piston rings by turning on a copying lathe, and describes both the method of production and the device used. The drawing shows a set *A* of partly-finished rings which are to be turned to a predetermined shape and are arranged with their outer contours in alignment on to a mandrel *B* and held by means of a pressure disc *C* and a nut *D*. The outer contour *E* of the collar or shoulder of the mandrel as well as



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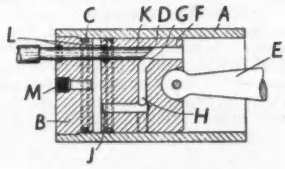
the outer contour *F* of the pressure disc *C* are formed in accordance with the shape to be imparted to the piston rings on a copying lathe. Rollers engaging the contours of the collar and pressure disc control the transverse movement of the turning tool. In order to prevent damage to the cutting edge of the turning tool, the guide contours may be made slightly smaller than the contour of the set *A* of piston rings to be turned. The arrangement of the contours *E* and *F* and pressure disc *C* results in an accurate and uniform distribution of pressure along the whole circumference of the piston rings. The projection *G* ensures the same position of the mandrel in relation to the spindle of the lathe and of the turning tool.—*June* 17, 1953.

AGRICULTURAL ENGINEERING

692,895. March 22, 1951.—HYDRAULIC LIFTING RAM FOR AGRICULTURAL IMPLEMENTS, André Louis Aurélien Morgen, 41, Rue des Capucins, Reims, Marne, France.

The hydraulic ram shown in the drawing comprises a cylinder *A* carried by the tractor and closed by an end piece *B* through packing rings *C* of synthetic plastic material. A piston *D* exerts pressure on a rod *E* which in turn acts through linkage to lift an agricultural implement. The tightness of the piston in the cylinder can be ensured by the usual piston rings or by the rings *C* of synthetic plastic material. The piston has a bore *F* parallel with the axis of the cylinder into which opens out at *G* a channel *H* whose other opening *J* is situated at the



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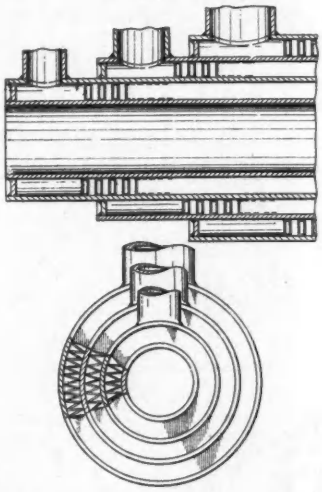
face of the piston which receives the pressure of the liquid. Through the end of the cylinder in the bore *F* can slide a rod *K* which may be either solid or hollow, the fluid tightness of which is assured by rings *L* of synthetic plastic material. A hand-control member allows the rod *K* to be given any desired longitudinal position relative to the piston. Assuming the rod to be pushed towards the right, the orifice *G* becomes closed and consequently a liquid under pressure admitted through opening *M* in the end wall of the cylinder will displace the piston *D* to lift the implement with a stress proportional to the pressure of the liquid until the piston has taken up, relative to the extremity of the rod *K*, the position shown in the drawing. When this happens the liquid escapes through the channel *H* and the free part at the right-hand end of the bore, with the result that the pressure falls and the movement of the piston is stopped. Thus the position of the rod *K* sets the height of the lift imparted by the piston.—*June* 17, 1953.

HEAT EXCHANGERS

692,885. December 12, 1950.—HEAT EXCHANGERS, Brown Fintube Company, Elyria, County of Lorain, Ohio, U.S.A.

Referring to the drawings, a heat exchanger made according to the invention consists of a number of concentric tubes which have annular spaces between. The ends of the annular spaces are closed by annular plates which are brazed or soldered to space the tubes, and communication between the annular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spaces and external elements is provided by connecting pipes. In order to provide extended heat transfer surface within the annular spaces for conducting heat efficiently and rapidly between fluids flowing in the annular spaces and the walls of the tubes, wound wire packings are arranged in the annular spaces. The specification describes the application of these wound wire packings and the general design of this type of heat exchanger.—*June* 17, 1953.

GAS AND STEAM TURBINES

692,867. March 24, 1950.—TURBINE BLADES, Hard Metal Tools, Ltd., Torrington Avenue, Canley, Coventry. (*Inventor : Edward Moor Trent*)

According to the invention, turbine blades are made of sintered hard alloys consisting of titanium carbide, a smaller quantity of chromium carbide and an auxiliary binder in the form of one or more of the metals nickel, cobalt and iron, as described and claimed in Specification No. 613,356. The present invention is largely based on the discovery that such blades also possess substantial resistance to creep.

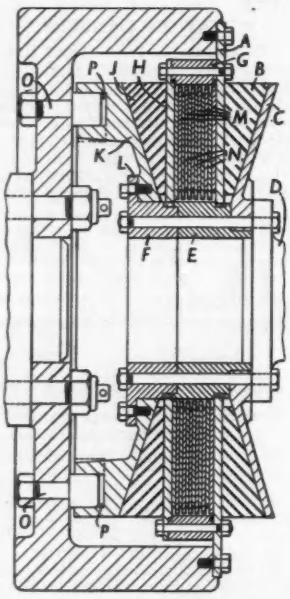
The alloy composition is maintained within the ranges of from 5 per cent to 12 per cent chromium

carbide and 20 per cent to 60 per cent auxiliary binder, the remainder being titanium carbide. The percentages are by weight of the alloy. Nickel is used as the auxiliary binder. The nickel content is most advantageous from 40 per cent to 50 per cent. As an example a turbine blade may be made from an alloy consisting of 54 per cent titanium carbide, 6 per cent chromium carbide and 40 per cent nickel. This alloy has the following properties: specific gravity, 6·15; hardness at room temperature, 800 V.P.N.; transverse strength at room temperature, 69 tons per square inch; creep strength (stress to cause fracture in 300 hours at 750 deg. Cent.), 13·5 tons per square inch; fatigue strength (stress to cause fracture in 40×10^6 reversals at 750 deg. Cent.), 14·2 tons per square inch; oxidation resistance, 0·010 grammes increase in weight per square centimetre of surface after 100 hours at 900 deg. Cent. in air.—*June* 17, 1953.

POWER TRANSMISSION

692,954. December 15, 1950.—FLEXIBLE COUPLINGS, Blackstone and Co., Ltd., Rutland Engineering Works, Stamford. (*Inventor: George Hallewell.*)

A feature of the invention is the provision of positive driving means incorporating a lost motion system so that the positive drive is only engaged on full allowable torsional movement of the resilient coupling. The flywheel of the engine carries an annular plate *A* which projects inwards from its rim. To the outer surface of the plate is bonded a rubber ring *B* of substantial thickness, which tapers in cross-section from outside to inside. To the outer tapering surface of the rubber ring is bonded a further annular plate *C* which is bolted to the flange of the driven shaft *D*; the bolts are elongated and serve also to attach an inner ring of similar diameter to the flange and which is made in two parts *E* and *F* and extends towards the flywheel. Bolts passing



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through the annular plate *A* carried by the flywheel extend through an outer annular spacing member or ring *G* and carry a further annular plate *H* which is bonded on its outer surface to a further rubber ring *J*. This rubber ring is similar cross-section to that described and is bonded to an annular plate *K* which is bolted near its inner edge to a flange *L* on the part *F* of the inner ring nearest to the flywheel. The structure is in effect two annular flexible couplings arranged between the engine flywheel and the driven shaft and held spaced apart by a two-piece inner ring *E* and *F* coupled to the shaft and an outer ring *G* coupled to the flywheel. Where damping of the variable torque of the engine is required, a series of annular discs *M* is anchored to the outer spacing ring *G* and is interleaved between a second series of discs *N* anchored to the inner spacing ring *E*. Sealing rings are provided between the inner annular plates of the couplings and the inner spacing ring *E*, and provision is made for filling the whole space between couplings with a fluid of requisite viscosity. To provide for a positive drive, to safeguard the rubber of the flexible couplings, a pair of bolts *O* whose heads protrude from the flywheel are set at 180 deg. around its axis. The heads of the bolts work freely in elongated circumferential slots *P* provided in lugs on the adjacent annular plate *K*, the length of the slots being sufficient to permit the full torsional movement allowable in the rubber of the couplings before engagement is made with the bolt heads.—*June* 17, 1953.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

NEW VALUE FOR THE ABSOLUTE VISCOSITY OF WATER AT 20 DEG. CENT.

No. 188 : 1937. Amendment No. PD1655. The British Standards Institution announce that on and after July 1, 1953, the value of 0·01002 poise for the absolute viscosity of water at 20·00 deg. Cent. will be adopted. This new value has recently been obtained by the National Bureau of Standards using improved means (see "The Absolute Viscosity of Water at 20 deg. Cent.," by J. F. Swindells, J. R. Coe and T. B. Godfrey, N.B.S., R.P.2279; Bull. 48, January, 1952) and replaces the hitherto adopted value of 0·01005 poise. This new value is being adopted in collaboration with the National Physical Laboratory and the Institute of Petroleum and coincides with its adoption in the U.S.A. by the National Bureau of Standards and the American Society for Testing Materials. Results of viscosity measurements made in accordance with B.S. 188, "Method for the Determination of Viscosity in Absolute (c.g.s.) Units," will be assumed, on and after July 1, 1953, to be based on the new value, i.e. 1·002 centipoises (1·0038 centistokes), and an amendment to Appendix C of B.S. 188 has now been published Reference P.D.1655 on the basis of the new value. This revised Appendix C gives a table of values for the kinematic and dynamic viscosities of water from 10 deg. to 60 deg. Cent. at 10 deg. Cent. intervals. The Institution in collaboration with the Institute of Petroleum, is revising B.S.188, consequent upon the decision to use water at 20 deg. Cent. as the sole calibrating liquid, instead of using 40 per cent and 60 per cent sucrose solutions of known relative viscosity. The use of water for all calibrations has been made feasible by employing the master or secondary viscometer for calibration purposes. The publication of the revised Appendix C of B.S. 188 is therefore only in the nature of a stop-gap until the revised standard is issued.

AIRCRAFT BOLTS WITH UNIFIED THREADS AND HEXAGONS

No. A.102-108: 1953. Price 3s. The British Standards Institution has published the following series of British Standards providing a range of bolts and nuts, of ¼in nominal size and above, with UNF threads and with hexagon dimensions agreed for aircraft use between representatives of the American, British and Canadian services and industries. This series of hexagon sizes differs from that of the "normal" series of Unified precision hexagon screws and nuts for general engineering purposes (covered by B.S. 1768 : 1951) in providing common dimensions for the hexagons of bolts and nuts of the same nominal size, and in the dimensions of hexagons for ¼in, ⅞in, and 1in nominal size bolts and nuts. The numbers and titles of the specifications are as follows:—

A.102: "Steel Bolts (Unified Hexagons and UNF Threads) for Aircraft." Price 4s.; A.103: "Steel Nuts (Unified Hexagons and UNF Threads) (Ordinary, Thin, Slotted and Castle) for Aircraft." Price 3s.; A.104: "Corrosion-Resisting Steel Bolts (Unified Hexagons and UNF Threads) for Aircraft." Price 3s. 6d.; A.105: "Corrosion-Resisting Steel Nuts (Unified Hexagons and UNF Threads) (Ordinary, Thin, Slotted and Castle) for Aircraft." Price 3s.; A.106: "Aluminium Alloy Bolts (Unified Hexagons and UNF Threads) for Aircraft." Price 3s. 6d.; A.107: "Aluminium Alloy Nuts (Unified Hexagons and UNF Threads) (Ordinary and Slotted) for Aircraft." Price 2s. 6d.; A.108: "Steel Bolts (Unified Hexagons, UNF Threads and Close Tolerance Shanks) for Aircraft."

These specifications contain general information on the material and the methods of manufacture to be used. The strength properties and the mechanical tests of the bolts are listed and where applicable heat-treatment requirements are detailed. Each standard includes numerous tables and diagrams in which the radii, diametral and longitudinal dimensions and proportions are listed. The squareness tolerance on the nuts is given, together with details of the squareness gauge and the method of identifying items with UNF thread is explained.

Contracts

BRUSH BAGNALL TRACTION, Ltd., has received an order from The Steel Company of Wales, Ltd., for ten diesel electric locomotives for heavy duty steel works operation.

CONTRACTS have been placed by the British Electricity Authority during the past month for equipment for power stations and transforming stations, amounting in the aggregate to £7,816,110. The principal contracts include: Acton Lane "B" power station, Willesden, one 30MW turbo-generator, feed water heating, condensing plants and auxiliary apparatus (Richardsons, Westgarth and Co., Ltd.); Brunswick Wharf power station, Poplar, generator and unit transformers (Metropolitan-Vickers Electrical Company, Ltd.); Deptford East power station, one 250,000 lb per hour boiler and ancillary equipment (Foster-Wheeler, Ltd.), one 52·5MW turbo-generator and auxiliary apparatus (Metropolitan-Vickers Electrical Company, Ltd.), and condensing and feed heating plant for one 52·5MW turbo-generator set (Vickers-Armstrongs, Ltd.); Hackney power station, ferro-concrete framework for precipitator house and cooling tower (J. L. Kier and Co., Ltd.); Brighton "B" power station, one 60MW turbo-generator set and condensing and feed heating plants (Richardsons, Westgarth (Hartlepool), Ltd.); Marchwood power station, near Southampton, five 60MW turbo-generators (English Electric Company, Ltd.); Portishead "B" power station, near Bristol, one 60MW turbo-generator, condensing and feed heating plant and generator and unit transformers (Metropolitan-Vickers Electrical Company, Ltd.); Ince power station, near Ellesmere Port, one 60MW turbo-generator (General Electric Company, Ltd.), and condensing and feed heating plant for one 60MW turbo-generator (Hick, Hargreaves and Co., Ltd.); Thornhill power station, near Dewsbury, Yorks, cooling tower (J. L. Kier and Co., Ltd.); Chadderton power station, Oldham, foundations and superstructure (Fred Mitchell and Son, Ltd.); Barony power station, Ayr, two 30MW turbo-generators (General Electric Company, Ltd.), and condensing and feed heating plant for two 30MW turbo-generators (Hick, Hargreaves and Co., Ltd.); and Castle Donington, near Derby, 132kV, 3500MVA switchgear (British Thomson-Houston Company, Ltd.).

Launches and Trial Trips

ALDEBARAN, minesweeper; built by Les Chantiers et Ateliers Augustin Normand for the French Navy; length overall 46·30m, breadth moulded 8·50m, draught 2·28m, displacement 424 tons; two sets of free-piston gas engines and double reduction geared gas turbines, 1800 h.p., speed 15 knots. Launch, June 27th.

DUNNET HEAD, coaster; built by Henry Robb, Ltd., for A. F. Henry and MacGregor, Ltd.; length between perpendiculars 180ft, breadth moulded 31ft, depth moulded to upper deck 15ft, deadweight 900 tons on 13ft 3in mean draught; two holds, MacGregor steel hatch covers, Clarke Chapman electric winches; one four-cylinder British Polar diesel engine, 640 b.h.p. at 250 r.p.m., two 40kW diesel generators, trial speed 10¼ knots. Trial, June 29th.

CALTEX PERTH, oil tanker; built by the Furness Shipbuilding Company, Ltd., for Overseas Tankship (U.K.), Ltd.; length between perpendiculars 515ft, breadth moulded 70ft, depth moulded 39ft 9in, deadweight 17,400 tons, summer draught 30ft 4½in, speed 15 knots; twenty-seven cargo oil tanks, one pump room, three 625 tons per hour turbo-driven cargo oil pumps and three 200 tons per hour vertical Duplex stripping pumps; two 300kW turbo-generators, one 75kW diesel generator, one set of Richardsons Westgarth double reduction steam turbines, 7300 s.h.p. at 100 r.p.m., two Foster-Wheeler "D" boilers supply steam at 450 lb per square inch. Launch, June 29th.

HAUSTRUM, oil tanker; built by R. and W. Hawthorn Leslie and Co., Ltd., for the Anglo-Saxon Petroleum Company, Ltd.; length overall 557ft, breadth moulded 69ft 3in, depth moulded 39ft, deadweight 18,000 tons; thirty-three cargo oil tanks, one pump room, four vertical centrifugal turbo-driven cargo oil pumps; one set of geared turbines, 8250 s.h.p., taking steam at 500 lb per square inch and 800 deg. Fah., two Foster-Wheeler boilers, two 550kW geared turbo-alternators, one 200kW diesel generator. Launch, June 29th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

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Fri. to Mon., Sept. 11th to 14th.—The University, Nottingham, 28th Annual Conference.

ILLUMINATING ENGINEERING SOCIETY

To-day, July 10th.—NOTTINGHAM CENTRE: The University, University Park, Nottingham, "Midlands Area" Summer Meeting.

INDUSTRIAL WELFARE SOCIETY

Wed., July 22nd.—Robert Hyde House, 48, Bryanston Square, London, W.1, "The Role of Women in American Industry," Miss Frieda S. Miller, 3 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Wed., July 15th.—LONDON GROUP: Visit by a party of members to the Vacuum Oil Company's Coryton Refinery, Essex, 1.45 p.m.

INSTITUTION OF MINING ENGINEERS

Wed. to Fri., July 15th to 17th.—Summer Meeting in Manchester.

OLD CENTRALIANS

Tues., July 14th.—Chez Auguste Restaurant, 47, Frith Street, London, W.1, "Concrete Technology," A. L. L. Baker, 12.45 p.m.